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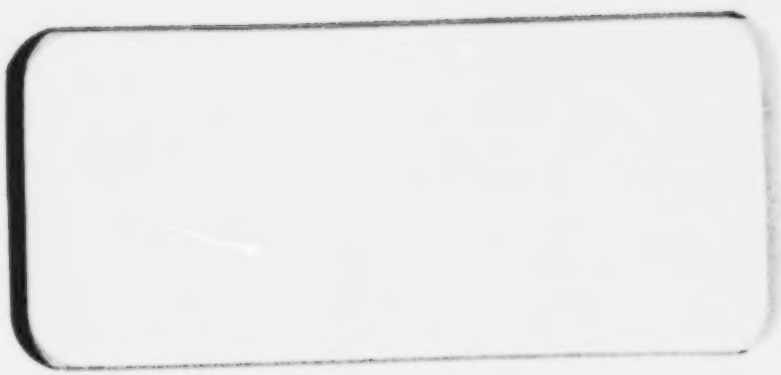

DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

CHARACTERIZATION AND CHEMICAL USE PATTERNS OF THE PAINTS AND COATINGS INDUSTRY IN BRITISH COLUMBIA

Regional Program Report: 85-09

By

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ABSTRACT

A characterization and chemical use patterns study of the paints and coatings industry was undertaken by the Environmental Protection Service in British Columbia in 1984-1985. The survey identified 43 firms which were classified into five groups; latex and alkyd, base resin manufacturers, pigment and additive importers and distributers, wholesale warehouse paint distributers, paint and coatings manufacturers and retail sales distributers. It was determined that there were no firms producing pigments.

Responses to the questionnaire identified that six organic priority chemicals were being used in paints and coating manufacturing including, di-n-butyl phthalate, di-n-octyl phthalate, dichloromethanes (methylene chloride), tributyl tin oxide, tributyl tin fluoride, and acrylic tributyl tin. Four additional organic priority chemicals detected in the sludges of two plants which were not identified in the questionnaire responses of any plant were dimethyl phthalate, diethyl phthalate, butyl benzyl phthalate and bis(2-ethyl hexyl phthalate).

Chemicals used in the paint and coatings production which are considered environmentally significant include phenyl mercuric acetate, copper antifouling agents, lead based pigments and driers.

The total annual volume of process wastewater generated in the industry is estimated at 615-1000 cubic meters with a maximum of 3.0-6.0% (28-56 cubic meters) sludge content. Spoiled batches of up to 568 cubic meters have been recorded and disposal of special wastes was to secure landfill in the United States. Waste reduction and product loss prevention techniques which were observed in operation at various plants are included in this report.

It is suspected that shipbuilding and repainting contribute significant quantities of organotins and copper based antifoulants to the marine environment. The effectiveness of immobilizing priority pollutants and heavy metals contained in paint sludges by fixing them in a cement matrix and disposing them to landfill has to be determined. A data report which includes plant effluent, sludge, sludge leachate, marine water and sediment analysis is attached as Appendix II.

RÉSUMÉ

Une étude des caractéristiques et des patrons d'usage chimique des industries de peintures et de revêtements, a été entrepris par le Service Protection de l'Environnement en Colombie Britanique en 1984-1985. L'enquête identifie 43 firmes classifiées en cinq catégories; latex et alkyde, manufacturieurs de résines de base, distributeurs et importateurs de pigments et additifs, distributeurs de peinture en gros, manufacturiers de peintures et de revêtements, distributeurs de vente au détail. Il fût déterminé qu'il n'y avait pas de firmes produisant des pigments.

Les réponses au questionnaires identifièrent que six produits chimiques organiques prioritaires étaient utilisés dans l'industrie manufacturière de peinture et revêtement comprenant les composés suivants: phlatate de di-butyle, phlatate de di-octyle, chlorure de méthylène, oxide de tri-butyl étain, fluorure de tri-butyl étain, fluorure de tri-butyl étain, acrylate de tri-butyl étain.

Quatre composés organiques prioritaires additionnels, détectés dans les boues de deux industries, qui ne furent pas identifiés dans les réponses du questionnaire d'aucune industrie, étaient le phlatate de di-méthyle, le phlatate de di-éthyle, le phlatate de benzyle et de butyle et le phlatate de bis-(éthyl d'hexyle).

Les produits chimiques utilisés dans la production de peintures et revêtements qui sont considerés significatifs environmentallement comprennent, de l'acétate de phényl mercure, des peintures antisallissure à base de cuivre, des pigments à base de plomb, et des siccatifs.

Le volume annual total d'eau usée produit par l'industrie est estimé à 615-1000 mètres cube avec un contenu maximum de 3.0-6.0% (28-56 mètres cube) de boue. Des lots gâtés, jusqu'à 568 mètres cube, ont été enregistrés et les déchets spéciaux furent disposés dans les sites d'enfouissement sécuritaires aux Etats Unis. Les techniques de prévention d'échappement des produits et de réduction des déchets qui furent observées durant les opérations à diverses installations sont inclus dans le rapport.

Il est soupçonné que la construction navale et le repeinturage contribue à incorporer des quantités significatives d'étain organique et de peinture antisallissure à base de cuivre dans l'environment marin. L'efficacité d'immobilisation, par fixation à une matrice de ciment, des produits polluants prioritaires et des métaux lourds contenu dans les boues, reste à être déterminée une fois disposée dans les sites d'enfouissement. Un rapport de données comprenant l'analyse des effluents industriels, boues, lessivages des boues, eaux marines et sédiments est attaché en appendice #2.

TABLE OF CONTENTS

		Page
ABSTRACT		i
RÉSUMÉ		ii
TABLE OF CONTENTS		iii
	List of Tables	vii
	List of Figures	viii
	List of Plates	ix
SUMMARY AND CONCLUSIONS		x
1.0	INTRODUCTION: ENVIRONMENTAL CONTAMINANTS ACT, PRIORITY AND CANDIDATE CHEMICALS	1
1.1	Characterization of the Paints and Coatings Industry	1
1.2	Industry Questionnaire	2
1.3	Site Inspections	2
1.4	Types of Firms Operating in British Columbia	3
1.4.1	Retail Sales Distribution	3
1.4.2	Wholesale Warehouse Distributers	4
1.4.3	Pigment Importers and Distributers	4
1.4.4	Resin Manufacturers	4
1.4.5	Paints and Coatings Manufacturers	5
2.0	PAINT AND COATING PRODUCTION	6
2.1	Blending of Dry Additives	6
2.2	Slurry and Bulking Tanks	7
2.3	Packaging	8
2.4	Plant Equipment Cleanup	9
3.0	RESIN MANUFACTURING	10
3.1	Oleoresinous Oils	10

TABLE OF CONTENTS (Continued)

		Page
3.2	Alkyd Resins	11
3.3	Amino and Urea Resins	11
3.4	Vinyl Resins	12
3.5	Acrylic Resins	12
3.6	Epoxy Resins	12
3.7	Polyurethane Resins	13
3.8	Chlorinated Rubber Coatings	13
3.9	Cellulosic Polymers	14
3.10	Phenolic Resins	14
3.11	Asphaltic Coatings	14
3.12	Silicon Based Resins	15
4.0	ADDITIVES	18
4.1	Driers	18
4.2	Fillers	19
4.3	Preservatives	19
4.4	Wetting Agents and Defoamers	20
4.5	Rubber Based Polymers for Specialty Paints	21
4.6	Plasticisers	21
4.7	Organic Pigments	22
4.7.1	Carbazole Violet	23
4.7.2	Carbon Black	23
4.7.3	Hansa Red-Yellow	23
4.7.4	Permea Cal Orange	23
4.7.5	Phthalocyanide Blue	23
4.8	Toners	24
4.9	Inorganic Pigments	24

TABLE OF CONTENTS (Continued)

		Page
4.9.1	Aluminum Based Pigments	24
4.9.2	Chrome Based Pigments	24
4.9.3	Cobalt	25
4.9.4	Cyanide Iron Blue	25
4.9.5	Iron Oxide	25
4.9.6	Lead Based Pigments	25
4.9.7	Molybdenum White	26
4.9.8	Titanium Dioxide	26
4.9.9	Zinc Based Pigments	26
4.9.10	Miscellaneous Pigments	27
4.10	Freeze Thaw Stabilizers	27
4.11	Viscosity Modifiers	27
4.12	Anti Settling Agents	31
4.13	Skinning and Antiskinning Agents	31
4.14	Flatting Agents	32
4.15	Defoamers	32
4.16	Antifloating Agents	32
4.17	Marine Paints	33
4.17.1	Industrial Antimicrobial Agents in Marine Paints	35
5.0	SOLVENTS	39
5.1	Hydrocarbons	39
5.1.1	White Spirits	39
5.1.2	Aromatic Hydrocarbons	39
5.2	Oxygenated Solvents	41
5.2.1	Acetone	41
5.2.2	Alcohols	41

TABLE OF CONTENTS (Continued)

		Page
5.2.3	Acetates	42
5.2.4	Ethers	42
5.3	Terpene Solvents	42
5.4	Paint and Varnish Removers	42
6.0	WASTE PRODUCTION AND TREATMENT	43
6.1	Treatment of Latex Wastes	43
6.2	Treatment of Solvent Wastes	46
6.3	Miscellaneous and Special Wastes	50
7.0	SPILL PREVENTION AND WASTE REDUCTION TECHNIQUES OBSERVED AT PAINTS AND COATINGS PLANTS IN THE PACIFIC REGION	51
7.1	Dry, Mixing Tank Cleanup Methods	51
7.2	Sprinkler Systems and Fused Valves.	51
7.3	Elevated Floor Drains	52
7.4	Spill Retention Sills and Drip Collection Trays	55
7.5	Raw Material Storage Areas	55
7.6	Liquid Raw Material and Product Storage Tanks	58
BIBLIOGRAPHY		60

LIST OF TABLES

Table		Page
1	ESTIMATED ANNUAL PRODUCTION IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA	16
2	ESTIMATED CONSUMPTION OF RESINS USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA	17
3	ESTIMATED CONSUMPTION OF ADDITIVES USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA	28
4	ESTIMATED CONSUMPTION OF SOLVENTS USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA	40
5	ESTIMATED ANNUAL WATER CONSUMPTION AND WASTE PRODUCTION IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA	44
6	ESTIMATED ANNUAL VOLUMES OF LATEX WASH WATER DISCHARGED TO SANITARY SEWAGE TREATMENT PLANT COLLECTION SYSTEMS	47

LIST OF FIGURES

Figure		Page
1	STEAM HEATED ASPHALT DRUM CLEANING	49
2	AUTOMATIC PRODUCT FLOW AND SPILL CONTROL BY HEAT SENSITIVE SPRING LOADED VALVE	53
3	SPILL CONTAINMENT WITHIN THE PRODUCTION BUILDING BY USING RAISED FLOOR DRAINS AND DOORWAYS	54
4	DRIP AND SPILL CONTAINMENT ON RAISED PRODUCTION MEZZANINE	56
5	SPILL CONTROL AT MEZZANINE STAIRWELL	57

LIST OF PLATES

Plate		Page
1	DEBRI COLLECTED IN A SEDIMENT GRAB NEAR A MARINE DRY DOCK	38
2	WASTEWATER SUSPECTED OF BEING CONTAMINATED WITH DYES AND/OR ANTIFOULING PAINT DISCHARGING DIRECTLY TO A HARBOUR FROM A MARINE DRY DOCK	38

SUMMARY AND CONCLUSIONS

The Environmental Contaminants Act (ECA) list of priority chemicals includes polychlorinated biphenyls (PCB's), chlorofluorocarbons (CFC's), chlorobenzenes, phthalic acid esters, chlorinated paraffins, chloroethanes, chloroethylenes chloromethanes and organotins. The candidate list includes aromatic amines, ethylenethiourea, halogenated diphenyl ethers, halogenated toluenes, nitrophenols, and organophosphorus compounds (see Appendix I). Some of these chemicals are used as preservatives, fungicides and plasticisers in the paints and coatings industry. A survey involving a questionnaire and site inspections to characterize the firms in this industry was made to determine use patterns for these chemicals.

Priority Chemicals

Six priority chemicals and five other groups of chemicals which are environmentally significant were identified as being used and they include:

1) di-n-butyl phthalate
2) di-n-octyl phthalate
3) dichloromethanes (methylene chloride)
4) tributyl tin oxide
5) tributyl tin fluoride
6) acrylic tributyl tin

Other Chemicals of Concern

1) Phenyl mercuric acetate
2) Lead based pigments
3) Chromium base pigments
4) Lead based driers
5) Copper based antifouling agents

Five types of firms were identifed in the survey and they include:

1) Latex and alkyd base resin manufacturers
2) Pigment and additive importers and distributors
3) Wholesale warehouse paint distributors
4) Paint and coatings manufacturers
5) Retail sales distributors

Of these, 24 firms were primarily involved with the manufacture of paints and coatings and 19 firms were primarily involved in operating distribution warehouses which would account for almost 100% of the quantity of coatings used in B.C.

Most additives and all pigments are imported into British Columbia and the distributors store these materials in tank farms which may be specifically designed for such products (as in the case of liquids) or in general multi-product warehouse complexes (as for pigments).

Solvent storage tanks are interior and exterior, above and below ground. The majority are exterior below ground tanks with no leak detection devices. None of the tanks inspected had leak detection devices or ground water monitoring wells and are vented to the ambient air. During product mixing the vapours are vented to the atmosphere under air permits but are rarely monitored for compliance, with odour being the primary concern. The major impact of solvents is expected to be from vapourization after application to substrates.

The industry survey determined that there are twenty-four firms primarily involved in the production of paints and coatings in British Columbia. The products produced include a wide range of applications from thick asphaltic coatings and household and specialty paints for chemical corrosion resistance and marine applications, to decorative cement and filler based wall coverings. An estimated volume of 31 506 000 l of liquid paints and coatings and in excess of 15 500 000 kg of putties, fillers and

cementous coatings are produced annually (see Table 1). An estimated 83 m^3 of sludges and solids are disposed annually to the Port Mann and other landfills. Special wastes are stored or shipped to secure landfill in the United States. A current inventory of 178 m^3 of alkyd and latex sludge is stored on site for reuse or (if cost effective) for disposal to secure landfill. 615-1000 m^3 of combined treated and untreated waste water (wash water and waste paint) containing 2.0-20.0% (45-90 m^3) solids is discharged to sanitary sewer. (A waste characterization study of several typical plant effluents is included as Appendix II.) An additional 4 800 m^3/y of miscellaneous waste which contains an undetermined amount of waste paint, paint skins and pigment in the form of residue on empty containers and packaging materials is disposed to landfill. Spoiled batch volumes of up to 568 m^3 have required disposal of over a period of several years to landfill sites in the United States.

Priority Additives: Di-n-butyl phthalate and di-n-octyl phthalate were two ECA priority plasticisers identified in the survey (Appendix I). A major portion of the estimated 16 000 l of di-n-butyl phthalate is used as plasticiser in filler and grouting material. Quantities released are not known and preliminary sampling is planned to determine if it is present in the environment near the coatings plants where it is used.

An estimated 61 400 kg/y of preservatives are used including copper oxides, mercurials, organochlorines and organotin compounds. Copper oxides are used as preservatives and antifouling agents in marine paints. Phenyl mercuric acetate is used as a mildewicide and fungicide in filler and grouting material and accounts for 44% of the total used. Organochlorines such as Dowicil 75 (1-(3-chloroallyl)-3,5,7-triazo-1-azoniaadamantane chloride) and pentachlorophenol are used as paint and wood preservatives. Organotins are used as antifouling agents in marine paints and antifungicides in interior paint where moisture is significant such as institutional kitchens and dairies. (1)

The major environmental impact of these materials is expected to occur during cleaning and reapplication when surfaces are cleaned by scraping or sandblasting.

Shipyards and steel fabrication yards have been cited for air pollution, odour and dust problems during sand blasting of these coatings for surface preparation and refinishing (12). The extent of this problem in British Columbia has not been documented however there are 34 shipbuilding and repair stations in Burrard Inlet, the lower Fraser River and Victoria and Esquimalt harbours.

Other Additives: An estimated 140 393 kg of drying accelerators including calcium, cobalt, copper, lead, manganese, zinc and zirconium napthenates are used. Approximately 30% of these being lead napthenates.

Waste Production and Treatment: Production of solid and liquid wastes varies from plant to plant and volumes of latex sludges range from nil to 14.4 m^3/y (70 barrels/yr). Liquid waste sludge from latex paint production is estimated at 83 m^3/y for 1984.

Some companies are able to recycle all the latex wastes into new product which may be a lower grade paint. Another method is dilution with cooling water and discharge to sanitary sewer. (The volume of waste is small in this case.) This is not permitted in all districts. The lack of a disposal site in B.C. and the high cost of disposal to the United States has forced some companies to recycle wastes into useful products. Several companies have tried to flocculate latex wash water however difficulty in solidification has forced them to revert to recycle procedures. Some companies use a second flocculation to obtain a product which will solidify.

Organic waste liquids are recycled if possible. Solvents which are not recycled into stain are sold as diluent in heavy fuel oil for use in ship and heating boilers. The quantity of waste resin, latex, and alkyd sludges which cannot be recycled is not expected to be large and insufficient information was provided to estimate the volume. Some companies are stockpiling sludges in preparation for recycle or in anticipation of a waste disposal site becoming operative in B.C.

An estimated 615-1000 m^3/y of process waste water is discharged to sanitary sewer. 35% (or 326 m^3) is collected by the Annacis Island sewage treatment plant. The waste water is a combination of supernatant from precipitation processes and wash water diluted with cooling water.

There were a number of safety features for the protection of workers and the environment and waste reduction techniques which were observed at various plants in B.C. They include dry tank cleaning techniques, sprinkler systems and fused valves, elevated floor drains, spill retention sills and drip collection trays. Raw material and product storage areas with adequate fencing and/or berms for protection from accident or vandelism.

Three accidental releases during 1984 caused short term fish and bird kills and undetermined long term affects. All of these could be attributed in part to improper spill prevention and containment planning. Examples of good planning which were observed at various facilities are included in this report to provide information to those responsible for plant security.

1.0 INTRODUCTION: ENVIRONMENTAL CONTAMINANTS ACT, PRIORITY AND CANDIDATE CHEMICALS

The Environmental Contaminants Act, list of priority and candidate chemicals includes certain chlorinated hydrocarbons, phthalic acid esters, organotins, aromatic amines, halogenated diphenyl ethers, halogenated toluenes, nitrophenols and organophosphorous compounds (see Appendix I). Chemicals listed are those of particular interest to the departments of the Environment and National Health and Welfare for special investigation to determine commercial/industrial use patterns, concentrations in the environment and health effects. Some of these chemicals were identified as being used in the paints and coatings industry and this report examines their use in British Columbia.

1.1 Characterization of the Paints and Coatings Industry

Characterization of the firms involved in the Paints and Coatings Industry required the consolidation of the available production and environmental information available. The documenting of companies still in operation was done by referring to such sources as:

a) Municipal telephone directories
b) Trade indices
c) Federal environmental files
d) Provincial environmental files
e) Province of B.C. Business Opportunities Sourcing System (BOSS) Index
f) Municipal business licence files

The companies identified were then grouped into three different classes:

1) Pigment and Additive Distribution (Supplying the Paints and Coatings Industry)
2) Paints and Coatings Distribution
3) Paints and Coatings Manufacturers

A computer file was created, containing the company's name, address, telephone numbers, drainage basin codes, and municipality. Each municipality or city was mailed a printout of the companies believed to be operating in their jurisdiction for confirmation, additions or deletions and request for environmental data relative to the operation. In most cases the list was referred to the business license office and very little environmental information was available. Several lower mainland municipal offices are converting to a computer data base with the capacity to store similar information. It was also found that some municipal fire departments are performing chemical inventories from a fire prevention and safety perspective. Future inventories should consider this source of information.

1.2 Industry Questionnaire

In co-operation with the Industrial Programs Branch EPS, in Ottawa an industry questionnaire was developed and tested by submission to several companies to fill out and comment. The Industrial Programs Branch was also responsible for contacting industry and trade associations such as the Canadian Paints and Coatings Manufacturers Association regarding the survey of their members in the Pacific Region and were provided with a copy of the questionnaire. After several revisions of the questionnaire company officials were contacted by phone to determine;

a) if they were actively involved in manufacturing, using priority or candidate chemicals.
b) the contact person to receive the questionnaire. This was very important to assure that the questionnaire was dealt with quickly by the most qualified person and reduce chances of it being lost.
c) an appointment to examine the facility first hand, observe handling procedures, answer inquiries regarding the questionnaire.

1.3 Site Inspection

Approximately 115 companies were contacted and 90 were visited over a seven month period. These included: 63 - General Plastics firms

(see Ref. 15); 4 - General Resin firms (see Ref. 15); 24 - Paint and Ink firms. The large number of visits were made to ensure that most variations in production were included and that none of the companies would feel that they were singled out and that a fair assessment would be made of the industry.

Five of these companies were selected for a preliminary sampling program to characterize wastes and determine possible routes of transport of priority chemicals to the environment. Two paint and coatings plants, two resin plants and one plastics plant were selected on the basis of;

a) size
b) process operations being typical for the industry
c) use of priority or candidate chemicals as defined in the Environmental Contaminants Act (7)

1.4 Types of Firms Operating in British Columbia

Five types of firms were identified in the paint and coatings survey of the Pacific Region and include:

1) Latex and alkyd base resin manufacturers (see Ref. 15)
2) Pigment and additive importers and distributers
3) Wholesale warehouse paint distributers
4) Paint and coatings manufacturers
5) Retail sales distributers

1.4.1 Retail Sales Distribution. Retail distributers of paints, coatings and stains include factory sales offices, manufacturers retail stores, lumberyards and some supermarkets. These facilities resell manufactured products and custom tint or pigment small volumes according to customer requests. The wastes produced are small in volume and are restricted to empty cans and minor spills.

1.4.2 **Wholesale Warehouse Distributers.** Wholesale distributers may do some specialty blending of small batches of paints or coatings. (Approximately 200 l batches). The majority of activity involves warehouse and distribution of finished product. Specialty tinting, pigmenting or repackaging may produce small volumes of waste paint and empty containers.

1.4.3 **Pigment Importers and Distributers.** Pigment importers and distributers ship bulk pigments and additives to the manufacturers. There are no pigment manufacturers located in British Columbia and almost all pigments are imported from eastern Canada or the United States. Material handling involves shipment of powdered additives in plastic or paper bags, cardboard or metal containers. Some companies ship from rented warehouses which can contain a wide variety of goods from food to chemicals and consumer goods. There are virtually no wastes from these facilities.

1.4.4 **Resin Manufacturers.** Resin manufacturers produce a wide variety of liquid carriers which range from water based to polymer based compounds. There are eleven major resin groups and they include:

1) Oleoresinous binders
2) Alkyd resins
3) Amino resins
4) Vinyl resins
5) Acrylic resins
6) Epoxy resins
7) Polyurethane resins
8) Chlorinated rubbers
9) Cellulosic polymers
10) Phenolic resins
11) Asphaltic resins

The precise definition of a resin is difficult as each group has multiple variation ranging from thin, liquid emulsions to thick non pour-

able compounds used for molding and plastic applications (6). Waste production is higher due to handling of bulk quantities of reactants, cleaning of reactors and tanks and filtration of products. This report will restrict itself to products specifically formulated for the paints and coatings industry (see Section 3).

1.4.5 Paints and Coatings Manufacturers. The industry survey determined that there are twenty-four firms primarily involved in the production of paints and coatings in British Columbia. The products produced were a wide range of applications from thick asphaltic coatings, to household and specialty paints for chemical corrosion resistance and marine applications, to decorative cement and filler based wall coverings. An estimated volume of 31 506 000 l of liquid paints and coatings and in excess of 15 500 000 kg of putties, fillers and cementous coatings are produced annually (see Table 1). An estimated maximum volume of 83 m^3 of waste sludge is produced annually. A further 4 800 m^3 of miscellaneous waste which contains waste packaging, general refuse, and an undetermined amount of waste paint and pigment in the form of residue on empty containers and packaging materials is disposed to landfill. 15-20 m^3 of special wastes resulting from spoiled batches are disposed each year in varying amounts and 178 m^3 is stockpiled until disposal is available. Spoiled batch volumes of up to 568 m^3 have been involved (see Table 5.0). This is disposed of over a period of several years at landfill sites in the United States.

2.0 PAINT AND COATINGS PRODUCTION

Paint and coatings production can be broken into two categories, physical production and chemical production. The physical production generally refers to the production of latex (water based) paints, drying oil (oleoresinous) paints and stains in mixing tanks. Chemical production refers to primary or secondary reactions carried out in reactors to produce alkyd (polyester based), amino, vinyl, acrylic, epoxy, polyurethane, chlorinated and phenolic resins. The base resin plants produce chemicals for the plastics and the coatings industry and reactions are detailed in references 1, 2, 6. The base resins are shipped in bulk via rail tanker, truck tanker or in barrels to paint manufacturers where additives are blended into the resin and production is essentially a physical mixing process. The six general stages of paint production include:

1) Dry additive blending
2) Pigment and additive wetting
3) Bulking with solvents
4) Packaging
5) Equipment cleaning
6) Shipping and distribution

2.1 Blending of Dry Additives

Dry additives such as fillers, pigments and viscosity modifiers are loaded into blending mills. Mill design varies however the most common is a rotating metal cylinder filled with metal balls of various sizes that are designed to pulverize and promote intimate mixing of the pigment. Powders are added through a loading port or chute and dusts generated by the displaced air are usually collected by a vacuum hood and filtered or in some cases discharged directly to the atmosphere. Mixing may also be done by pouring reactants simultaneously into a turbine mixer where a rotating blade agitates and dispenses the streams of powder as they fall

into the cylinder. Ball mills are the most common for dry blending and after the products are loaded the mill is sealed and allowed to rotate for up to 8 to 10 hours. The heat generated by friction is removed by cooling water which is discharged to storm sewer in most cases. None of the plants visited recycled the cooling water. High speed dispersion blenders are replacing ball mills for pigment mixing operations. The pigment storage and/or blending areas of all but one plant visited in British Columbia were subject to extensive spillage and dust. Most of this spilled material is carried throughout the process area by personnel and vehicular traffic. The one plant where no dust was evident was a new facility which had been operating for over four years and had several dust control features. These included a dust collection hood over the pigment weigh area which was connected to a central dust and fume collection system. At all locations where pigments or dusts were handled there were brooms and collection equipment stationed to be used if any spill were to occur.

Wet mills are similar to dry mills with the exception that the pigments are blended in a resin slurry before being filtered, bulked with resin and/or solvent. Accidental spillage of the pigment mixtures and screenings containing miscellaneous wastes and particle conglomerates are the waste produced in this area. Volume of waste material is usually very small if proper procedures are followed.

2.2 Slurry and Bulking Tanks

Paint blending may be a one or two stage process. A two stage process involves the blending of all the basic ingredients with the resin carrier before the mixture is pumped to a larger tank to be thinned with solvent. A carrier resin (or binder) is filled into a blending tank via a pump and header system which feeds liquids from interior or exterior, above or below ground storage tanks. None of the underground tanks at any of the plants visited had leak detection devices on the tank works. There were no groundwater wells for leak testing. The general attitude was that tank leakage would be noticed by unaccountable material loss or that infiltration by groundwater may result in cloudiness of the resin.

Some resin components are added manually from metal drums and others are measured by volume or weight into small containers before being added to the batch. Additive drum storage varied greatly from plant to plant. Some facilities stored the barrels in a horizontal position with no collection trays or buckets under the spigots. This resulted in leakage and contamination of the work area (see Section 7.4).

Mixing tanks range from 1000 l to 22000 l or larger. In most cases liquid additives and resin components are added prior to bulking the paint to the desired volume. Fumes and dusts are produced when additives are poured into the tanks and most facilities had fume hoods over the mixing tanks to vent fumes directly to the atmosphere.

The high sheer forces imposed by the blending blades also generate heat which may require cooling water to prevent polymerization of certain alkyds. In all cases the cooling water was discharged to storm sewers.

After the slurry is mixed, additional resin and/or solvent may be added. Depending on the scale of the operation, the slurry may be transferred to bulk liquification tanks for final addition of resins, and/or solvent and additives. Most of the plants in British Columbia use mobile tanks to which all the ingredients are added and blended to specifications before transport to the packaging lines.

2.3 Packaging

Filling lines vary from manual systems where valves are hand operated and cans are sealed by hand to fully automated systems in which cans are machine filled and pressure sealed. Spillage of paint due to carelessness or machine malfunction is a possibility with all systems and most plants had cleanup equipment and absorbants on hand. The used absorbants are disposed in the general refuse and quantities cannot be estimated. Some facilities use pressurised equipment with protective shields to guard against overfilling and can explosion. Spill containment is

simple, consisting of waste cardboard packaging or drip collection buckets stationed at strategic points. Wastes collected are intermittent, of low volume and are disposed to landfill.

2.4 Plant Equipment Cleanup

All paint production facilities require equipment washing and cleanup to remove residual blends and prevent cross contamination of products. Alkyd paints and production lines are washed with alkyd or mineral spirit solvents and latex paint production lines are washed with water rinses and/or dry cleanup methods. The alkyd washings are reused, redistilled or shipped to recyclers for blending into bunker fuel. Latex washings are reused, treated or disposed to sanitary sewer (see Section 6).

3.0 RESIN MANUFACTURING

Base resin manufacturing generally requires reactor equipment for the production of asphaltic, oleoresinous, rubber, plastic and latex resins or emulsions. The reactors usually consist of a large sealable tank equipped with access ports, agitator, controls, pressure release mechanisms, heating and/or cooling systems, and condensor apparatus if required. In most cases the reactants are preweighed and charged to the reactor. The contents are agitated by a high powered mixing propeller to control reactions by promoting intimate contact, avoiding hotspots and maintaining heating and cooling systems.

Hot compressed air may be injected to oxidise asphalt or oleoresinous oils to produce higher viscosity oils. Rubber or plastic/water emulsions are produced by specific control of reaction conditions where microscopic beads of polymer are formed in a water suspension with polymerization controlled by temperature, catalysts, free radical generators and absorbers, surfactants and reaction time. Polymerization can continue even after removal from the reactor and during transport so that reaction inhibitors are added and storage time before final processing is kept to a minimum.

3.1 Oleoresinous Oils

Oleoresinous oils are the oldest used coating material and include natural vegetable oils which are long chain fatty acids. Linseed oil (raw, boiled or oxidised), tung oil, and soya oil are used in British Columbia (see Table 2). Other oils which may be used include olive, soybean, dehydrated castor, tall oil (2), castor, coconut, cottonseed and oiticica oils (1). The active agents are the unsaturated double bonds of linolenic, linoleic and oleic acid.

There are three types of oils: drying, semi drying, and non-drying. Drying oils have a high degree of unsaturation and crosslink

to a hard film by reaction with atmospheric oxygen. Semi-drying oils have lower degree of unsaturated double bonds which takes longer to crosslink and forms a softer film. Nondrying oils are composed of saturated fatty acids which form films by dehydration rather than oxidation.

All oleoresinous oils are slow drying and may be blended with metallic soaps such as calcium, cobalt, copper, lead, manganese, zinc or zirconium napthenates (see Table 3 and Section 4.1). The maximum metallic content in the salt is 36% and film addition rates are 0.25% to 0.5% based on solid content (1).

3.2 Alkyd Resins

Alkyd resins are formed by a condensation between a polyhydric alchohol and a carboxylic acid or anhydride (1, 2). This is a typical polyester formation. The resin can be modified with drying or non drying oils. Those blends which use higher concentrations of oils are normally used for trade and retail alkyd paints. The low oil content, modified alkyds are used in industrial finishes and laquers which are baked on. The baking is required to promote film formation through crosslinking and produces a harder glossy finish. Alkyd resins can be combined with urea and melamine resins to produce high grade finishes. In British Columbia the base alkyd resin production is produced at one location in the Greater Vancouver Regional District and distributed to producers. Other producers import and distribute through warehouse operations.

3.3 Amino and Urea Resins

Amino resins are formed by a condensation reaction between an aldehyde ($R-C\overset{O}{-}H$) and an amine ($R-NH_2$) or amide ($R-C\overset{O}{-}NH_2$) (1). Melamine is reacted with formaldehyde to produce a resin suitable for a heat stable, high gloss baked finished. Urea formaldehyde resins are brittle and can be modified with alkyd resins and plasticisers and are used for metal finishes.

Chemicals used in British Columbia include urea, di-methyl aniline, di-ethyl-aniline, melamine, formaldehyde and urea formaldehyde resins.

Both dimethyl and di-ethyl aniline are ECA candidate chemicals and are used at an estimated rate of 1000 kg/yr and 10 000 kg/yr respectively. Anilines are known to be toxic (8).

3.4 Vinyl Resins

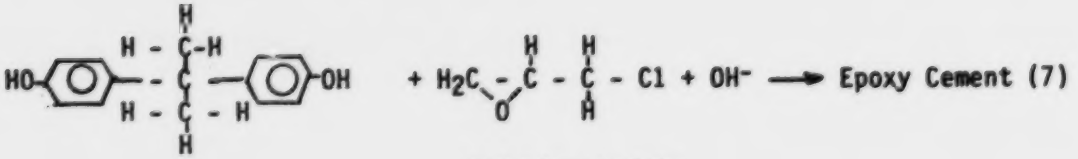
Vinyl resins can be formulated from polyvinyl chloride (PVC), polyvinyl acetate (PVA) or copolymers of both. The coatings are produced by solvating the prepolymer in ester or ketone solvents (2). The PVC resins are more difficult to dissolve and provide better corrosion resistance. Solubility increases with an increase in PVA content of the co-polymer (2). A small volume of vinyl resins (28 400 l) are produced in British Columbia (see Table 1).

3.5 Acrylic Resins

Acrylic resins are thermoplastic resins which are polymerized using acrylic and methacrylic esters (2). (Methyl methacrylate has a vinyl and methyl ester bond and can completely polymerize to produce a hard thermoplastic clear structure which can be used to produce glasses such as "Lucite" or "Plexiglass" (1).) These can be combined with melamine, epoxy alkyd resins to produce corrosion resistant coatings (2). The volume of acrylic resins produced in B.C. are estimated at 21 500 l.

3.6 Epoxy Resins

Epoxy resins are based on epichlorohydrin bisphenol resins.



2,2-Bis (p-hydroxyphenyl) propane (Bisphenol A)

Epichlorohydrin

These are chain structured with aromatic groups and are joined by ether groups (R-O-R') (2). Approximately 28 000 l/yr of epoxy resin based coatings are produced in British Columbia as a base for marine paint (see Table 1). Epoxy resin is imported and blended for use as a decorative clear finish for furniture such as wood burl table tops, crafts, hobby kits and counter tops or formulated into industrial maintenance coatings for the protection of steel.

3.7 Polyurethane Resins

Polyurethane coatings are formulated to produce protective interior and exterior coatings. The properties range from thin rubber like coatings to clear interior and exterior finishes for wood. The general classes of urethane resins are:

1) amine catalysed two container system (2)
2) moisture cured urethane (2)
3) urethane (aliphatic) oils and alkyds (2)

The first group is cured by an amine catalyst, in the second group moisture in the air cures the paint (2).

An estimated 18 260 l of two component urethane insulating resin systems and 600 000 l of moisture cured urethane coatings are produced annually in B.C. Approximately 60 000 l of aliphatic urethane based coatings are imported into the region and small volumes of aliphatic resins are custom blended for specific applications.

3.8 Chlorinated Rubber Coatings

Specialty anticorrosion chlorinated rubber coatings are formulated in B.C. Chlorinated compounds such as chloro-ethylene, monochloro-undecane and polychloroprene are handled in estimated amounts of 1300 kg, (trace), and 6600 kg respectively. An estimated 15 200 kg of

miscellaneous rubber coatings are blended annually. Chlorinated compounds are ECA priority chemicals however the amounts used are small and mono-chloro undecane is only used in trace quantities.

3.9 Cellulosic Polymers

Cellulose nitrate was previously used in large quantities in fast drying laquers but has been replaced by synthetic polymers (1). Nitrocellulose is produced by nitrating cotton fiber in nitric acid and is produced in RS (Regular soluble) and SS (spirit soluble) grades (2). It forms a clear film and is used commercially as a plasticised material in aromatic and aliphatic hydrocarbons. Film formation is by evaporation and approximately 4750 l of nitrocellulose dissolved in ethyl acetate, methyl isobutyl ketone is used in coatings production in British Columbia.

3.10 Phenolic Resins

There are two types of phenolic resins which can be used as coatings. Pure phenolics are phenol formaldehyde resins which are used mostly as glue for plywood production. It can also be used for chemical, alkali and alchohol resistant coatings for tanks, patios and furniture (2).

Modified phenolics are ester linked resins. An estimated 22 500 l are produced in B.C. for coatings. Phenolic resins may be combined with drying oils such as linseed or tung oil to produce varnishes.

3.11 Asphaltic Coatings

Asphalt based coatings are produced for use in outdoor applications such as tennis courts and patio surfaces as well as waterproofing, wood preservation, road surfacing and pipeline anticorrosion applications. The coatings may be solvent or emulsified latex blends. The colors used for asphaltic coatings are limited to chrome oxide greens, iron oxide reds or titanium dioxide greys and asphaltic black. Fillers of powdered clay and grit material such as sand and mica are used to provide surface

texture. An estimated 1 173 000 l of asphaltic coatings and 1 365 000 l of emulsion coatings are produced in B.C.

3.12 Silicone Based Resins

Silicone resins are crosslinked networks derived from the hydrolysis of trichlorosilanes and dichlorosilanes. Surface coating resins generally contain methyl or phenyl radicals. None of the facilities surveyed in B.C. indicated the production of silicone based coatings and it is believed that all such products are imported into the region.

TABLE 1 ESTIMATED ANNUAL PRODUCTION IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA*

COMPOUND	ESTIMATED AMOUNT (liters)
Latex Paint	9 152 300 l
Alkyd Paint	17 683 700 l
Clear Coatings	727 000 l
Laquers	464 200 l
Emulsion Resins	1 365 000 l
Asphaltic Coatings	1 713 000 l
Rubber Based Coatings	79 900 l
Paint and Varnish Removers	320 760 l
Putties, Fillers	> 15 500 000 kg

*Totals do not include paint imported for distribution.

TABLE 2 ESTIMATED CONSUMPTION OF RESINS USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

RESIN	CONSUMPTION
Raw Linseed Oil	3 943 000 l
Boiled linseed oil	64 000 l
Oxidised linseed oil	52 400 l
Soya Oil	11 550 l
Tung Oil	10 300 l
Alkyd resins	3 044 000 l
Vinyl resins	62 000 l
Epoxy resins	< 30 000 l
Polyurethane resins	15 300 l
Phenol formaldehyde resins	34 000 l
Acrylic resins	209 000 l
Urea	4 000 000 kg
Melamine Formaldehyde	< 15 000 kg
Dimethyl analine	1 000 kg
Diethyl analine	10 000 kg
Poly methylmethacrylate	3 000 kg

4.0 ADDITIVES

A mixture of resin, pigment and solvent is not likely to have the properties required to make it a good coating which is easy to apply, durable or has the appropriate surface characteristics. There are more than 17 classes of additives which may be included in the formulation to control colour, colour fastness, ultraviolet degradation, and rheological properties. Other additives include plasticisers, preservatives, biocides, fungicides, antifouling agents and combustion inhibitors. A wide variety of toxic substances such as heavy metals, chlorinated organics, phthalic acid esters and organotin compounds are used in these additives and have been detected in the waste streams of some plants. The types and estimated quantities of the chemicals used in B.C. are outlined as follows.

4.1 Driers

Driers are metallic salts that aid in the crosslinking of unsaturated bonds in oleorisinous binders by acting as oxidation agents. Table 3 lists seven organo-metallic compounds which were identified as being used in the Pacific Region. They include calcium, cobalt, copper, lead, manganese, zinc and zirconium napthenates.

Cobalt drier is formulated as 6% to 12% cobalt metal and is used as a surface film drier. Lead napthenate is formulated at 24% to 36% lead metal and acts as a polymerization catalyst for drying the film crossection. Manganese is a film drier with 6 to 12% metal content. Calcium possesses similar film drying properties as lead and enhances the performance of lead when used in combination (1). Calcium driers are used in 4 to 6% metal concentrations and are being used to replace lead for the manufacture of lead free paints. Zirconium is used as a lead substitute and is sold in 6 to 18% metal concentrations (2).

The concentration of driers in the paint blend is critical and ranges from 0.025% for cobalt to 0.5% for lead, based on the solid content of the binder (1). Solid content in a paint blend may be very low for stains to 55-60% for some paints (10).

4.2 Fillers

Extenders and fillers are relatively inert materials that do not contribute significantly to the color or opacity of the paint film. Table 5 lists the eight types of fillers identified in the Pacific Region. They are added to provide bulk, modify rheology and mechanical properties such as surface texture, gloss, abrasion resistance and permeability of the film. Various clays form the bulk of the filler consumed. Other fillers include barytes, calcium carbonate, mica, polystyrene, silica, talc and miscellaneous materials. The finely powdered dusts create a problem during handling and blending into the paint formulation. These dusts are usually controlled by a variety of vacuum fume heads, filters and baghouse systems.

4.3 Preservatives

Preservatives are used as antifungal, antibacterial and anti-fouling agents to protect the paint while it is being formulated, stored and after application (see also Section 4.17 Marine Paints). The very function of these chemicals require that they are toxic to living organisms. Fungicides used include organotin compounds, mercury, copper, lead, pentachlorophenol, N-(trichloromethyl) thiophthalimide, and organo chlorides (such as Dowacil 75). The quantities used in the Pacific Region are listed in Table 3.

Latex paints use water as a major ingredient and require the addition of biocides and/or fungicides to prevent contamination. Bacteria in the paint produce enzymes which degrade the macromolecules into products which can be assimilated by the bacteria (1). Thickners such as cellulose ether are particularly susceptible to bacterial attack. Raw materials must not be contaminated by enzymes which can cause paint degradation even in the absence of bacteria. Fungi may grow in paint stored in cans and cause gas build up and putrefaction. They can grow in painted interior and exterior surfaces, particularly when relative humidity exceeds 70%. Walls and surfaces in dairies, kitchens and washrooms are particularly

susceptible and paints are specifically formulated for these areas. Biocides are added at a rate of 0.05% to 0.3% of the weight of the paint (1).

Organomercurials such as phenyl mercurial acetate (PMA) are used in marine paints as antifouling agents. The coatings are designed so that the primer layer of the paint contains the organo mercury compound which leaches through the pigmented surface layer over the service life of the paint (1, 11). The constant leaching of mercury, copper oxide, metallic copper, or tributyl tin oxide at the paint surface is toxic to organisms such as algae or barnacles. These materials are designed to slowly escape to the environment and in the case of mercury are toxic to higher organisms and their use is restricted to exterior applications.

Organotin compounds are less toxic to higher organisms than organomercurials and are used for interior applications (1). Compounds such as dibutyl and tributyl tin oxide are used at a rate of 8 800 kg/yr. Dosage is approximately 1% of total solids (1).

Zinc oxide is a fungicide that has pigmenting properties and consumption is estimated at 86 750 kg/yr (see Table 3, Inorganic Pigments 4.9). Effective dosage is 30% to 40% of solids (1) and current use is as a pigment with antifungal side benefits.

A list of antimicrobial paint additives for use in Canada is found in Appendix III. Barium metaborate, dithiocarbamates and dichlorofluamides may also be used. Barium metaborate is used at 15% to 20% addition for external use (1). Dithiocarbamates and dichlorofluamides are used in interior and exterior applications at application rates of 1.5 to 2% of total solids.

4.4 Wetting Agents and Defoamers

Wetting agents are required to evenly disperse the pigment in the resin carrier and produce a uniform film. The wetting agent must remove water and exclude gases from the particle to allow the carrier solvent (or resin) to adhere to the particle. The surface active agent (surfactant) is either hydrophilic (water soluble) or oleophilic (oil soluble) or both in

the case of promoting an oil in water emulsion paint. Approximately 246 000 l of surfactants and defoamers are consumed in B.C. (see Table 3). Chemicals which may be used include:

hydrophilic - long chain condensation products of fatty acids (1)
- sulfonated oils (1)
- metallic soaps of carboxylic acids (1)

oleophilic - short chain condensation products of ethylene (1)
- oxides of fatty acids and amine or ammonium compounds (1)

Concentrations of these compounds are typically from 0.1 to 0.5% of paint solids (1).

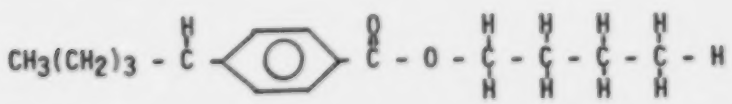
4.5 Rubber Based Polymers for Specialty Paints

Corrosion resistant sealing paints are usually chlorinated rubber emulsions. Crepe rubber is masticated and solubilized in carbon tetrachloride or chloroform at 80°C to 100°C (1). This yields a stable compound with 60-65% chloride content. Materials used in the Pacific Region include polychloroprene, chlorethylene, monochloro-undecane and other miscellaneous rubber compounds (see Table 3).

4.6 Plasticizers

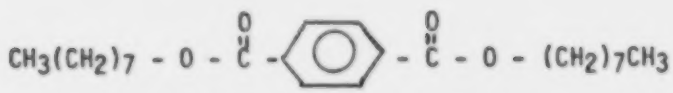
Plasticizers are added to increase or maintain film flexibility and are usually low volatility oily compounds. Two plasticizers identified in the Pacific Region are di-n-butyl-phthalate and di-octyl-phthalate which are ECA priority chemicals.

di-n-butyl-phthalate, DBP, $C_6H_4(COOC_4H_9)_2$
C.A.S. No: 84-74-2 (5)



Used as a plasticiser in nitrocellulose lacquers (4)

di-n-octyl-phthalate, DOP, $C_6H_4(COOC_8H_{17})_2$
C.A.S. No: 117-84-0



Used as a plasticiser in vinyl compounds

Estimated maximum consumption is 15 400 l and 3 790 l respectively. Plasticiser concentrations can range from a few percent to a major portion of the resin binder and can react with it. Secondary plasticisers are limited in solvent capacity of the resin and are generally not reactive with the resin. They act as lubricants for the macromolecular film by separating the molecular chains within the fused structure.

Di-n-butyl-phthalate is a plasticiser used in nitrocellulose resins and polyvinyl acetate emulsions. Addition rates are 10-20% for emulsions and 20-50% (by weight) of the nitrocellulose resins (1). Dioctyl phthalate (DOP) is used in nitrocellulose and polyvinyl chloride systems. Other plasticisers which may be used but were not indicated in questionnaire responses are triphenyl phosphate, tricresyl phosphate, trichloroethyl phosphate, butyl stearate and chlorinated paraffins (1). All of these are ECA priority or candidate chemicals.

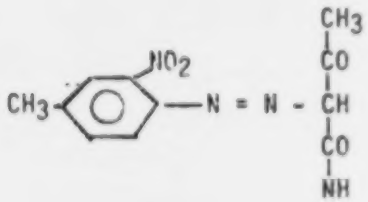
4.7 Organic Pigments

Organic pigments are manufactured into fine, high purity powders which produce clean, intense colors but have low opacity (1). There are no pigment manufacturing plants in the Pacific Region however a wide range of pigments are imported and used (see Table 3). The response by paint companies to quantity information regarding pigments was poor. Most companies stock a small amount of a wide variety of pigments and did not indicate the usage. Some responses were very comprehensive and consumption estimates were based on these responses and other literature. Total annual consumption of organic pigments is estimated at 104 300 kg.

4.7.1 Carbazole Violet. Carbazole violets have good heat resistance are non-bleeding and high tinting (2).

4.7.2 Carbon Black. Carbon blacks are produced by incomplete combustion of mineral, vegetable and animal matter (1). Only 15 to 30 kg/m^3 are used to pigment paint (2) and it is not known to be toxic.

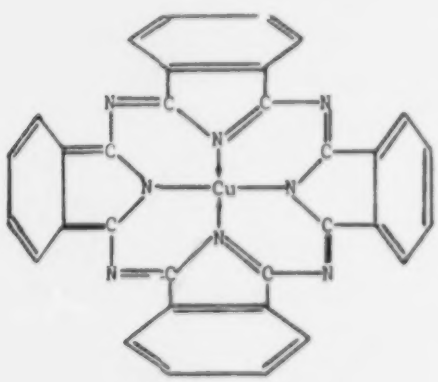
4.7.3 Hansa Red-Yellow. Hanza pigments belong to the azo group and range in color from red to green. The typical structure is:



4.7.4 Permea Cal Orange. No data available.

4.7.5 Phthalocyanide Blue. Phthalocyanide pigment shades vary from red shade blue to green shade yellow. A typical pigment is made from heating an intimate mixture of phthalic anhydride, urea and cupric chloride (1).

A typical structure is given below (1).



4.8 Toners

Toners are organometallic complexes which are ionic salt like compounds derived from a reaction between a metal or a metallic salt and a dyestuff containing an acid group (1). Very little toner is used in the region.

4.9 Inorganic Pigments

Inorganic pigments include metal flake, metal oxides and sulfides and multimetal complexes such as blue and green pigments. Table 5 shows that total consumption is estimated at 3 504 000 kg/yr.

4.9.1 Aluminum Based Pigments. Aluminum paste is used as a protective coating for metal structures and as reflective metal flake in paints. Consumption is estimated to be 8 000 kg/yr. Antimony oxide ($Sb0_3$) is almost exclusively used in fire retardant paint (1). It is white in color and minimum consumption is estimated at 600 kg/yr but is expected to be higher.

4.9.2 Chrome Based Pigments. Chrome green has the formula $PbCrO_4$ + $Fe(NH_4)Fe(NC)_6$ with the toxic ingredients being lead, chromate and cyanide. Annual consumption is estimated at 1 800 kg. The color shades range from light yellow green to dark blue green. This pigment was used in large quantities however consumption has declined due to restrictions on leaded paints (2). Chrome oxide green has the formula Cr_2O_3 with the toxic component being Cr_2O_3. Annual consumption is estimated at 4 700 kg. The color is a dull green with high infrared reflectivity which finds application in camouflage paints. Chrome yellow has the formula $PbCrO_4$ with lead and chromate being the toxic components. Annual consumption is estimated at 174 000 kg with 80% (140 000 kg) in road marking paint and 20% (34 000 kg) for marine and machine enamels. The color range is from green yellow to red yellow (2). Lead content restricts consumption of this pigment to exterior applications.

4.9.3 Cobalt. Cobalt has a blue to violet colour range, low tinting properties and can be used as a fungicide. Consumption is estimated at 1700 kg/yr.

4.9.4 Cyanide Iron Blue. Iron blue pigments are cyanide complexes having the formula $KFe(Fe(CN)_6)$ (Prussion blue) or $Fe(NH_4)Fe(CN)_6$ (Iron Blue). These are high tinting pigments with cyanide as the toxic component. Annual consumption is estimated at 73 000 kg.

4.9.5 Iron Oxide. Iron oxides are red brown pigments with the formula Fe_2O_3. This pigment is used as color for timber stains, low cost metal primers, fillers for cement and concrete (1) and as pigment for asphaltic paints used in tennis courts. An estimated 170 500 kg are consumed annually with typical loading rates of 240 kg/m^3 of paint (2).

4.9.6 Lead Based Pigments. Basic lead silicate (or basic lead silica chromate) is a synthetic inorganic pigment with the chemical formula $PbO:CrO_3:SiO_2$ (1). This pigment has a dull orange color with low tinting power and is used in primers and protective coatings for steelworks. The estimated consumption is 18 000 kg/yr and the toxic components are PbO and CrO_3. White lead has the chemical formula $2PbCO_3Pb(OH)_2$ and is synthetically produced. The basic nature of the pigment causes it to react with oleoresinous material such as oils found in wood. Consumption is estimated at 3 000 kg/yr and the toxic component is lead. Red lead litharge has the formula $PbO_2 \cdot 2PbO$ and is synthetically produced (1). It is basic and will react with oleophinic oils such as linseed oil in a saponification reaction producing lead soap. The higher the PbO content the greater the tendency to cause thickening during storage. The main use is in protective primers for metal works. Lead is the toxic component of the pigment and consumption is estimated at 13 500 kg/yr (For lead chlorinate see 4.9.2 Chrome Based Pigments).

4.9.7 Molybdenum White. Moly white is synthetically produced and the annual consumption is estimated at 24 000 kg.

4.9.8 Titanium Dioxide. Titanium dioxide is a synthetic inorganic pigment which at an estimated consumption of 2 894 000 kg/yr accounts for almost 75% of the total pigment consumption in the Pacific Region. TiO_2 has replaced white lead pigments which were used for their low cost and exceptional durability (especially in wood paints) but have been banned for most uses due to toxicity.

An exceptionally high refractive index of 2.5 to 2.7 (1) accounts for good opacity in paint films and loading rates are 240 to 359 kg/m^3 (2) in most applications. Most paints are pigmented with titanium dioxide and then tinted to the correct color prior to use. It is considered nontoxic (1) and is used in the food packaging industry, childrens toys and dairies as well as domestic and commercial applications.

4.9.9 Zinc Based Pigments. Depending on the prepatory method zinc chromate yellows can have different formulations.

1) Zinc oxide + Potassium dichromate + Hydrochloric acid
$ZnO + K_2CrO_4 + HCl \longrightarrow 4ZnCrO_4 \cdot K_2O \cdot H_2O$
which is used for colouring except in anticorrosive paints (1).

2) Chloride free pigment is produced by stripping from the pigment or using chromic acid to produce $K_2CrO_4 \cdot 3ZnCrO_4 \cdot Zn(OH)_2$ (1). This pigment is used in anti-corrosion application.

3) Zinc tetroxy chromate has the formula $ZnCrO_4 \cdot 4Zn(OH)_2$ (1) and is used in anticorrosion applications

Estimated consumption is 8 850 kg/yr and chromium is the major and zinc is the minor toxic compound.

Zinc oxide is a synthetic white pigment which is basic and can react with oleophinic resins. Reactivity is high and can cause brittleness. It has antifungal properties and requires loading rates of 30% by weight of film for effectiveness (1). It is used as a mildewicide in exterior paints and consumption is estimated at 75 750 kg/yr. Zinc yellow has the chemical formula of $4ZnO \cdot K_2O \cdot 4CrO_4 \cdot 3H_2O$ with CrO_4 as the toxic component. Consumption is estimated at 19 550 kg.

4.9.10 Miscellaneous Pigments. Most paints and coatings producers stock small amounts of a wide variety of pigments that are used sporatically depending on seasons or special orders for specific applications. A more comprehensive inventory is required to determine the hundreds of possible pigments which may be used. The types suspected as being used include:

1) Toluidene reds
2) Benzidene yellows, oranges
3) Basic lead sulphates
4) Cadmium yellows, oranges, reds
5) Arylamide reds

4.10 Freeze-Thaw Stabilizers

Freeze-thaw stabilizers or antifreeze agents are chemicals that lower the freezing temperatures of the formulated coating. These include glycols such as ethylene, propylene (2) or hexalene glycol. These chemicals can also be used as resin components to form polyester linked macromolecular films. Other stabilizers include soaps which prevent separation of phases in an emulsion.

4.11 Viscosity Modifiers

The viscosity of a paint (its tendency to flow) can be modified to the requirements dictated by the methods of application. Spray applied

TABLE 3 ESTIMATED CONSUMPTION OF ADDITIVES USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

ADDITIVE		ESTIMATED CONSUMPTION
Driers (Metallic Soaps)		
Calcium Napthenate	Trend is to synthetic acid based complexes (13)	37 500 kg
Cobalt Napthenate		25 700 kg
Copper Napthenate		2 800 kg
Lead Napthenate		44 000 kg
Manganese Napthenate		8 800 kg
Zinc Napthenate		13 593 kg
Zirconium Napthenate		8 000 kg
Fillers		
Barytes ($BaSO_4$)		N/A
Calcium Carbonate ($CaCO_3$)		1 482 000 kg
Clays ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$)		17 530 000 kg
Mica ($K_2O \cdot 2Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$)		56 600 kg
Polystyrene		5 000 kg
Silica (SiO_2)		217 400 kg
Talc ($H_2Mg_3(SiO_3)_4$)		> 426 000 kg
Miscellaneous		5 000 kg
Preservatives		
Dowicil 75		3 300 kg
Organotins		8 800 kg*
Mercury (as PMA)		24 700 kg
Mercury (as PMO)		NO DATA
Pentachlorophenol		3 600 kg
Miscellaneous Fungicides		22 700 kg
Defoamers and Detergents		246 000 l
Polymers		
Chloroethylene		1 300 kg
Monochloro-undecane		N/A
Polychloroprene		6 600 kg

* expected to be higher as several major users did not report values

CONTINUED...

TABLE 3 ESTIMATED CONSUMPTION OF ADDITIVES USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

(Continued)

ADDITIVE	ESTIMATED CONSUMPTION
Polymers (Continued)	
Potassium Tri Poly*	< 500 kg
Miscellaneous Rubber Compounds	15 200 kg
Plasticisers	
Di-n-butyl phthalate	16 000 l
Di-n-octyl-phthalate	3 790 l
Triphenyl phosphate	1 760 kg
Tricresyl phosphate	80 kg
Others	7 896 kg
Caustic	
Caustic potash	100 kg
Amines	90 kg
Ammonia	5 500 kg
NaOH	33 900 kg
Wetting Agents	
Soya lecithin	50 000 kg
Sodium salts	10 000 kg
Containing phenol	3 600 kg
Organic Pigments	
Carbazole violet	1 960 kg
Carbon Black	32 600 kg
Hansa Red	7 400 kg
Hansa Yellow	7 500 kg
Permea Cal Orange	1 500 kg
Phthalocyanide Blue	5 100 kg
Phthalocyanide Green (copper)	2 400 kg
Miscellaneous Pigments	35 000 kg
Organic dyes	140 kg
Toluidene red	10 700 kg

*Trade Name

CONTINUED...

TABLE 3 ESTIMATED CONSUMPTION OF ADDITIVES USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

(Continued)

ADDITIVE	ESTIMATED CONSUMPTION
Inorganic Pigments	
Aluminum Paste	8 000 kg
Antimony Oxide	600 kg
Burnt Umber	6 600 kg
Chrome green $PbCrO_4$ + $Fe(NH_4)Fe(NC)_6$	1 800 kg
Chrome oxide CrO_3	4 700 kg
Chrome yellow $PbCrO_4$	174 000 kg
Cobalt	1 700 kg
Cyanide iron blue	73 000 kg
Iron oxide	170 500 kg
Lead (Basic) silicate	18 000 kg
Lead White	3 000 kg
Lead (Red) Litharge	13 500 kg
Molybdenum white	24 000 kg
Titanium dioxide	2 894 000 kg
Zinc chromate	8 850 kg
Zinc oxide	86 750 kg
Zinc yellow	19 550 kg
Miscellaneous pigments	84 000 kg
Anti Skinning Agents	
Methyl ethyl ketoxime	14 000 l
Acids	
Hydrochloric acid	1 320 kg
Oxalic acid	< 1 500 kg
Others	
Freeze Thaw Stabilizers	
Ethylene Glycol	150 700 l
Propylene Glycol	46 400 l
Hexalene Glycol	900 l

coatings require lower viscosity whereas high build brush applied coatings may be extremely thick with little tendency to flow. The three main modifiers used are natural clays, thixotropic resins and cellulose ethers (1).

Natural colloidal silicates (Bentonite clays) can be treated with organic amines and used as thickners in solvent systems. The resulting polar molecular structure causes thickening of the paint. Addition levels are 2-4% by weight of paint (1) and consumption is estimated at 17 530 000 kg/yr.

Thixotropic resins decrease in viscosity with increased applied sheer force and can be formed by reaction between an alkyd resin or oil and a polyamide (1).

Cellulose ethers have swelling characteristics when dissolved in water and can be used to increase the viscosity of latex paints and emulsions. The most common ones used are ethyl hydroxy ethyl cellulose and sodium carboxy methyl cellulose. Thickening characteristics occur at addition levels of greater than 0.25-1.0% by weight of the paint (1).

4.12 Antisettling Agents

Pigments are subject to settling during storage and resuspension requires additional time and energy input and may not result in even dispersion. Antisettling agents may be used to control this phenomenon.

Soya lecithin is a surface active agent which absorbs to the pigment surface, increases its volume and decreases its density. Addition levels are at 1% of the pigment content (1) and consumption is estimated at 3850 l/yr. Certain grades of calcium carbonate powders coated in an organic film may be used as an anti packing agent. The larger particles result in loose settlement which is easier to redisperse (1). Total consumption of $CaCO_3$ is 1 482 000 kg/yr for this and other purposes.

4.13 Skinning and Antiskinning Agents

Anti skinning agents are volatile antioxidants which act by preventing surface oxidation of an applied paint film. If they are not used a

surface film would form by reaction with atmospheric oxygen slowing or preventing volatilization of the solvent. This would result in excessive drying times, and a soft subsurface layer. The volatile anti skinning agents continuously migrate to the surface until the entire layer has dried. The most common ones are methyl ethyl ketoxime ($CH_3N(OH)C_2H_5$) in alkyds and butyraldoxime ($C_4H_9N(OH)H$) in oleoresinous liquids (2). Phenolics may be used however they impart excessive drying times (2).

4.14 Flatting Agents

Flatting agents control the gloss level of a dried coating. In pigmented paints, flatness is easier to control than in clear varnishes or laquers. Amorphorus silica can be used to produce this effect (2). Consumption of silica for this and other purposes is 166 000 kg/yr.

4.15 Defoamers

Defoaming agents are used to decrease occlusion of air during mixing and application. Foaming is a problem in latex paints and results in insufficient volumes in cans during filling and bubble formation in films during brush application. There are three types of defoamers and they include solubilized surfactants, soft particle and hard particle (2). Solubilized surfactants include fatty acid and fatty alcohol surfactants which modify surface tensions and may impart a physical shock factor during bubble collapse. Soft particle defoamers include paraffinic waxes and fatty amides which may operate by physical action. Hard particle defoamers include silica or silicon coated minerals and act by physical breaking of bubbles. None of the companies specifically indicated the type of materials they use and they are not expected to be ECA priority or candidate chemicals.

4.16 Antifloating Agents

Paints are generally blended with a white base color and then pigmented or tinted with a mixture of colors to a desired endpoint.

Variation in pigment densities may cause separation of colors during storage which can be altered by the addition of silicons or other anti separation agents. None of the companies surveyed indicated the use of such compounds.

4.17 Marine Paints

Anticorrosion and antifouling paints are the two major types of marine coatings. Variations of these can be formulated which serve both purposes.

Anticorrosion paints protect by both physical and chemical actions. The high salt and mineral content of salt water accelerates corrosion by improving conductivity in electrochemical reactions. (The same reactions but at slower rates can occur in freshwater). Physical protection of a coating results from sealing the surface from oxygen and from abrasive wave action carrying suspended sediment and sand. Chemical protection involves the use of sacrificial anodes for galvanic type corrosion.

Antifouling paints inhibit the growth of aquatic organisms such as slimes, algae and barnacles which can cause structural damage through increased drag, reduced freeboard and clogging of water intakes and filters. Marine growths can cause a galvanic type of corrosion through the formulation of oxygen concentration cells. Areas covered by the growth have less oxygen than exposed areas and a small electrical voltage created by differences in oxygen concentration can cause corrosion.

Marine paints (except for two component systems) are formulated from the three basic components found in most paints.

1) Solvent: Oil or water based, used to disperse the resin binder and pigment also facilitates application and film formation. With increasing concerns over photochemical smog and worker health concerns in both manufacturing and application sectors the market for water based paints is increasing.

2) Resin: For binding the pigment and film formation after the solvent has evaporated.

3) Pigment: Provides color and opacity to protect the resin binder from ultraviolet degradation.

Two component formulations cure by chemical reaction rather than by dehydration or atmospheric oxidation. These paints include epoxies, coal tar epoxies, urethanes and polyesters. Some of these formulations can be applied under water to perform repair work over small areas which extends the service life of a coating before the structure must be dry docked and cleaned. The two coating formulations most often used for underwater surfaces are urethanes and epoxies because of their superior resistence to degradation. The other major types of marine coatings are as follows:

Vinyls: These are durable coatings that require an organic solvent. They can be repaired or recoated, however the solvents are known to contribute to photochemical smog (12).

Chlorinated Rubbers: Are extremely durable coatings which use strong solvents (Xylene, Toluene). They are high build coatings (i.e. form thick layers with one application) (12).

Epoxies: Are durable coatings although some have a problem with chalking (formation of a surface dust). This chalking must be removed before recoating is performed (12).

Coal Tar Epoxies: Coal tar epoxies are limited to black or shades of grey. They are subject to chalking and ultraviolet degradation (12).

Urethanes: Polyester, polyether, and acrylic cured urethane complexes have good light stability and low temperature curing properties.

Polyesters: Polyesters have a wide ranging application as a paint and as a structural material when combined with fillers, glass or carbon fibers. Many boat hulls, and marine works are constructed of polyester/glass or filler composites and coated with polyester paints called gel coats (12).

Inorganic Zincs: Zinc coatings are used as anticorrosion films. The zinc is powdered and dispersed in the binder for application as a mid layer. The zinc particle acts as a sacrificial anode which preferentially corrodes rather than the steel or metal structure. The oxidation rate is very high when in contact with the steel structure so that zinc is applied as a mid layer film. A primary film is used to seal the structure, the second layer contains the zinc and an outer layer provides protection and color. The outer layers are generally vinyls, epoxies or urethanes.

4.17.1 **Industrial Antimicrobial Agents in Marine Paints.** There are two types of antimicrobial systems used in marine paint formulation. One operates using low surface energy and the other by leaching of toxic components at the surface of the film.

The low surface energy paints are "slippery" coatings which act by reducing the surface area which is suitable for microbial attachment (11). Tetra-fluoroethylene may be one example. These formulations are in an experimental stage and not widely used.

The most common antimicrobial coating involves the leaching of toxins from the paint film. A high concentration of toxin is applied as an undercoat or intermediate film. A semi permeable top coat is applied over the preservative film. In service, the concentration difference of toxin in the paint film over that in the water creates an osmotic pressure which allows the toxin to leach into the water. The constant leaching creates a film which is toxic to organisms and prevents marine growth. The service life of the film is limited to physical abrasion and the concentration of toxin remaining in the film.

Organo mercury such as phenylmercuric acetate (PMA), phenylmercuric oleate (PMO), organo leads, and arsenics were widely used as antimicrobials and "in can" presentations. These are being replaced due to their toxicity during production, handling, application and resultant bioaccumulation and biomagnification properties once introduced into the food chain. PMA, lead primers and arsines are still used in paint production in British Columbia.

The two major compounds used are organotins and/or copper based antimicrobials. Organotins which may be used included tributyl tin fluoride (10), tributyl tin oxide and acrylic tributyl tin. They are sold as 12-100% active ingredients and are added at concentrations of 5-20% (10). Black, neoprene rubber impregnated with tributyltin is used as a covering for marine structures (13). A high build layer (up to 2 mm) can be impregnated with a high concentration of organotin. (The use in B.C. has not been determined).

Cuprous oxide is widely used as an antifouling agent (10) and is incorporated into the paint film as a leaching agent. Annual consumption could not be estimated due to lack of data from questionnaire responses. Due to galvanic corrosion with steel, an insulating undercoat is first applied to the structure before the copper layer. Galvanic corrosion prevents the use of copper based paints on aluminum structures. Formulations require concentrations of copper of 30-70% based on the weight of the paint (11).

Rosin (which is mainly a mixture of C_{20} and fused ring monocarboxylic acids (11)) is used as a leaching film for CuO (12). A complete list of registered antimicrobial paint additives for use in Canada is included in Appendix III (16).

Shipyards and steel fabrication yards have been cited for air pollution, odour and dust problems during sand blasting of these coatings for surface preparation and refinishing (12). The extent of this problem in British Columbia has not been documented however there are 34 shipbuilding and repair stations in Burrard Inlet, the lower Fraser River and Victoria and Esquimalt Harbour. The number in other centers has not been

determined. Some preliminary sampling of benthic sediments has been done for metals, polychlorinated biphenyls and dioxins. These analysis have not been completed and the data is unavailable at publication. Potential sources of marine pollution were observed during the sampling trip. Plate 1 shows a paint roller retrieved in the first sediment grab sample taken near a dry dock in Esquimalt harbour. Plate 2 shows seepage and wash water suspected of being contaminated with tracer dyes and/or antifouling paints, discharging directly into marine waters. Careless disposal practices and the release of sandblasting grit materials containing fragmented paint chips and heavy metals are potential sources of pollution from this industry. Examination of the material handling and waste disposal procedures of the major shipyards should include comprehensive sampling of residues from sandblasting operations and benthic sediments near them.

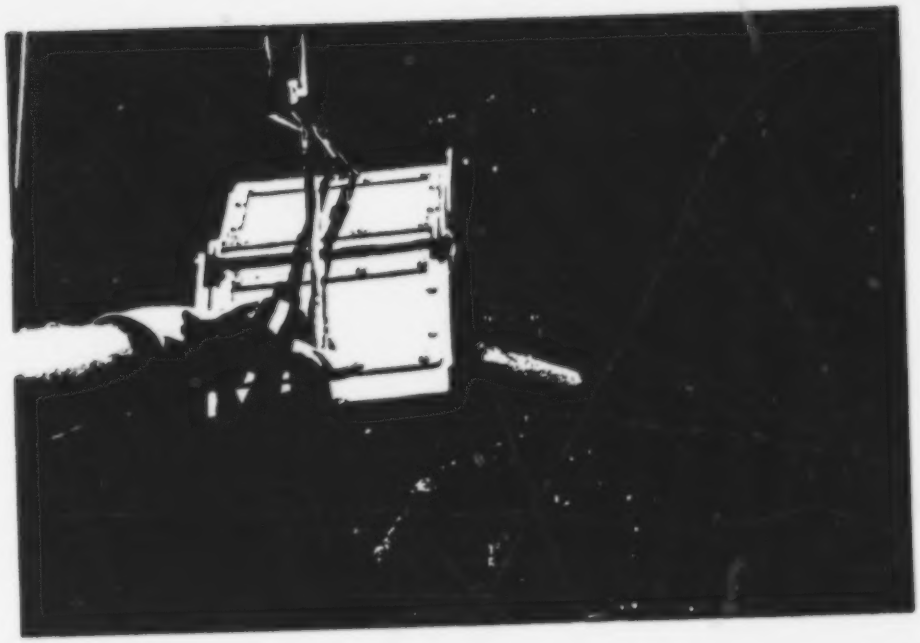


PLATE 1: DEBRI COLLECTED IN A SEDIMENT GRAB NEAR A MARINE DRY DOCK

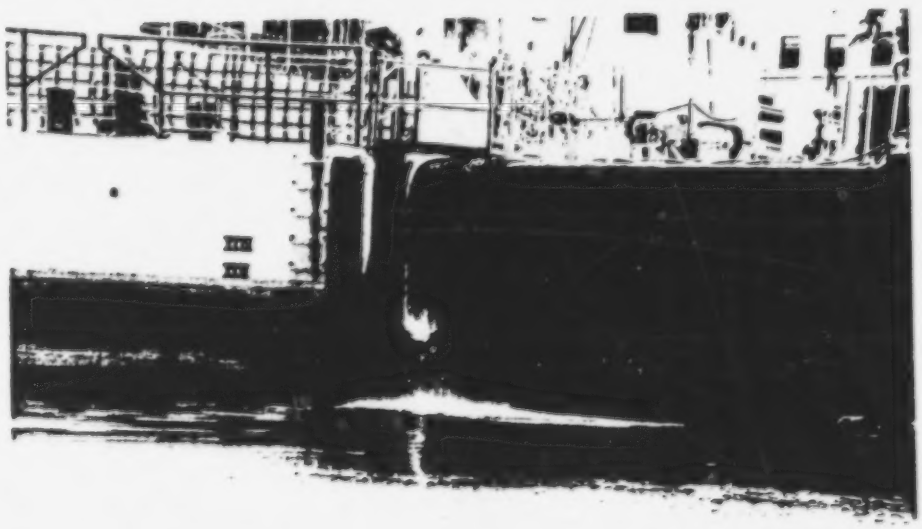


PLATE 2: WASTEWATER SUSPECTED OF BEING CONTAMINATED WITH DYES AND/OR ANTIFOULING PAINT DISCHARGING DIRECTLY TO A HARBOUR FROM A MARINE DRY DOCK

5.0 SOLVENTS

The basic function of the solvent is to disperse the resin carrier and pigments in a homogenous mixture and deposit them in an even film on a substrate. There are three types, a true solvent, latent solvent, diluent and an undefined class that can act as a solvent or resin. A true solvent tends to dissolve the film forming resin while a latent solvent acts as a true solvent when mixed with a true solvent. A diluent does not react with the resin but is tolerated by it.

5.1 Hydrocarbon Solvents

Hydrocarbon solvents are often referred to in the industry as spirits, mineral spirits, and white spirits (1, 2, 3). They consist of a blend of distillate fractions from petroleum crude oils and are generally broken up into boiling point ranges. The fast evaporating types are used in laquers and specialty industrial paints (2), intermediate grades are for trade and commercial sales (1, 2), and the heavy grades are used for protective anticorrosion applications (3).

5.1.1 White Spirits. White spirits are the intermediate grades of hydrocarbon solvents containing approximately 82% to 85% aliphatic hydrocarbons and 15% to 18% aromatic hydrocarbons (1). It is the main solvent for a major fraction of all coatings produced. Consumption is estimated at 9 435 000 l/yr. (May also be called Kerosol, Varsol or Shellsol depending on the suppliers trade name. Kerosol is the slowest evaporating mineral spirit.)

5.1.2 Aromatic Hydrocarbons. Phenol, toluene, toluidene, xylene and naptha were the five aromatic hydrocarbons identified in the survey. Toluene ($C_6H_5CH_3$, may be called Toluol in industry) is used as a solvent for air drying copolymer formulations for vinyl and chlorinated rubber paints. Consumption is estimated at 365 000 l/yr.

Xylene ($C_6H_4(CH_3)_2$, may be called Xylol in industry) is a slower evaporating solvent used for some laquers and industrial paints to

TABLE 4 ESTIMATED CONSUMPTION OF SOLVENTS USED IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

SOLVENT	
Mineral spirits (in product)	9 509 000 l
Mineral spirits (for resale)	159 000 l
Acetone	25 750 l
Methanol	81 000 l
Anhydrous Ethanol	49 600 l
n-propyl Alcohol	3 500 l
Iso-propyl Alcohol	13 700 l
n-propyl Acetate	450 l
Ethylene glycol monoethyl ether*	160 000 l
Phenol	11 000 l
Toluene	563 000 l
Toluidene	900 l
Xylene	326 000 l
Rubber solvent	230 l
Methylene Chloride	52 800 l
Naptha	< 20 000 l
Solvated Nitrocellulose**	18 000 l
Miscellaneous Naptha's	100 l
Paint and Varnish removers	11 600 l

*Cellosolve

**Likely dissolved in ethyl acetate

solublize polyurethanes, chlorinated rubber, vinyl copolymers, alkyds and modified alkyds. It is also used for stove cured formulations and consumption is estimated at 304 000 l/yr.

Toluidene ($C_6H_4CH_3NH_2$ or amino toluene or methyl aniline) is used in small quantities in specialty industrial formulations. Consumption is estimated at 900 l/yr. This compound is an ECA candidate chemical and was used in limited quantities.

Phenol (C_6H_5OH) is a toxic substance (9) that is used as a wetting agent in proprietary formulations and is a raw material in phenolic resin films. Consumption as a direct additive (not as a resin) is estimated at 11 000 l/yr.

Naptha's are a blend of faster evaporating aromatics which are used for spray applied industrial paints and laquers. Consumption was less than 20 000 l/yr.

5.2 Oxygenated Solvents

Oxygenated solvents are a variety of low density, high vapour pressure liquids comprising ketones, alcohols, esters, ethers and glycol ethers. The chemicals indicated as being used in British Columbia are listed as follows.

5.2.1 Acetone.

Acetone (CH_3COCH_3) is a ketone solvent which is extremely volatile with high solvation power. It is used in vinyl copolymers and nitrocellulose paints (1). Consumption is estimated at 25 750 l/yr.

5.2.2 Alcohols.

Methyl alcohol (CH_3OH), ethyl alcohol (CH_3CH_2OH), n-propyl ($CH_3CH_2CH_2OH$) and isopropyl alcohol were all indicated as being used in the paints and coatings industry. These are volatile in laquers and industrial coatings (2). Consumption is estimated at 27 000 l/yr, 49 600 l/yr, 3 550 l/yr and 2 700 l/yr, respectively.

5.2.3 Acetates. N-propyl acetate ($CH_3COOC_3H_7$) is a medium boiling solvent which is used in industrials and laquers. Consumption is estimated at 450 l/yr. Butyl acetate ($CH_3COOC_4H_9$) may be used as a solvent but was not indicated in the survey. Both can be used as solvents for nitrocellulose resins (2).

5.2.4 Ethers. Glycol ether or cellosolve are industry names for ethylene glycol - monoethyl ether ($CH_3CH_2OCH_2CH_2OH$). It has a low vapour pressure and is used as a solvent for brush applied systems which cannot tolerate aliphatic hydrocarbons. Consumption is estimated at 160 050 l/yr.

5.3 Terpene Solvents

Terpene solvents are derived from the sap of the pine tree and includes turpentine, dipentene and pine oil (20). None of these products were identified by any companies in the survey however turpentine is believed to be distributed in the region.

5.4 Paint and Varnish Removers

Solvents such as varsols and methylene chloride are repackaged as paint and varnish strippers for sales to the general public. Approximately 32 500 l of methylene chloride, 11 600 l of unspecified dry paint, and varnish removers and 159 000 l of (varsol type) wet brush, roller and paint cleaners are sold annually.

6.0 WASTE PRODUCTION AND TREATMENT

Waste production by paints and coatings manufacturers varies from plant to plant and depends on the nature of the products which they produce. Volumes of sludges or effluents from production plants range from nil to over 100 m^3/yr and they may or may not receive treatment.

6.1 Treatment of Latex Wastes

Waste liquids are generated during solvent and latex paint productions and depending on plant policy the residuals may or may not be recycled. Latex washwater frequently contains hydroxy-ethyl or methyl cellulose that supports the growth of cellulose decomposing bacteria which depend on enzymes to convert the cellulose into digestible products. Paint decomposition can occur even if the bacteria are absent and the enzymes are left in the water causing paint spoilage and putrifaction in the can. Latex wash water is therefore handled in three ways depending on the company.

Immediate disposal of latex wash water occurs if the risk of contamination is high. This can occur due to contaminated water supply, poor handling practices, production scheduling requiring lengthy storage times or lack of storage space. Immediate dumping is usually restricted to older plants where the production systems were not designed for recycle. In these cases the wash water is discharged to a floor sewer and/or sump and may or may not receive treatment before discharge. This is restricted to a few small flows of relatively inert materials under supervision of municipal permits.

In at least one case the waste discharge has been to an underground field drainage system which resulted in contamination of the soil with lead, mercury, chromium and other heavy metals which were added to paint formulations as pigments and preservatives. The possible spread of these metals in the ground water has not been determined. These discharges have been discontinued.

Plants which produce a wide variety of custom latex formulations claim that the small quantities of multiple formulations make it difficult

TABLE 5 ESTIMATED ANNUAL WATER CONSUMPTION AND WASTE PRODUCTION IN THE PAINTS AND COATINGS INDUSTRY OF BRITISH COLUMBIA

COMPONENT	QUANTITY
Water in Product	9 030 m^3/y
Cooling Water	23 800 m^3/y
Sanitary Water	5 835 m^3/y
Liquid Waste (and Solidified) Sludge	83 m^3/y
Special Wastes Stored on Site	178 m^3
Solid Miscellaneous Waste	4 800 m^3/y
Special Waste (spoiled batches)	568 m^3*

*This waste resulted from a product recall and could not be reformulated therefore it is being disposed in small batches to secure landfill in the United States.

to store the washings and produce a low grade paint within economic constraints and avoiding bacterial contamination. Plants which produce standard formulations find scheduling of production and recycling easier due to the fewer variables in the waste.

In British Columbia the treatment which is applied to waste latex includes holding in settling tanks and discharge to sanitary sewer or flocculation and solidification with discharge of the supernatant to sanitary sewer. Flocculation involves the storage of waste latex washwater in a mixing tank. Alum flocculant is blended in the water and allowed to precipitate the solids. The supernatant is withdrawn and discharged to sewer with no further treatment. Flocculation may be repeated to obtain a sludge suitable for solidification. Several companies have attempted to flocculate the waste however poor separation and excessive solidification times for the flocculant/cement binder have prevented this. In several cases the companies found that they were able to recycle the wastes when other disposal methods failed. Solidification is achieved by the addition of a cement binder which is mixed into the sludge in waste metal drums. After the cement is cured the drums are disposed to landfill. Curing may take up to one month or more. Approximately 16 m^3/yr of solidified sludge is disposed to the Port Mann Landfill in Surrey. The analysis of the latex waste water, flocculant, supernatant discharge and solidified matrix is currently underway and the results will be published in a supplemental report.

Some plants will store latex washwater for a maximum of 24 to 72 hours before it is discharged. Bacteria tests are made on all latex products at the beginning, mid, and final blending stages and at selected periods during packaging and storage. If the latex washings are unpreserved they can be recycled into new interior latex batches. Higher concentrations of preservatives are used in exterior paints and scheduling of production is often done with only 24 hours of lead time depending on market conditions. If the washings are not heavily preserved then the use is more flexible. If the wash cannot be used in the specified time period it is discharged to sanitary sewer with lower chemical concentrations

requiring treatment and smaller loss of raw materials representing unrecoverable costs to the company. Minimizing the volume of wash water produced is an important means of control of wastes which must be disposed. Most paint production occurs in tank sizes of 900 to 23000 l (200 gal to 5000 gal) and one company has found that three rinses of the tank at a maximum of 23 l (5 gal) per rinse is sufficient to clean the tanks. This requires a policy of enforcement and co-operation by management and staff but is successful in reducing waste water volumes.

In some cases the wash water which is discharged to holding sumps is flushed to the sanitary sewer by cooling water from the mixing mills. This prevents the build up of solids which could shock load the sewer system.

Table 6 lists the estimated distribution volumes of latex waste to the various sewage treatment plants in the major production areas. Annacis Island STP receives 35%, Iona Island STP receives 35% and Lulu Island STP receives 25% of the 930 m^3 of process waste water discharged annually. The solids loading is estimated at 28-56 m^3/yr. Effluent sampling at selected sites has been done to determine chemical components and loading characteristics are included in Appendix II.

6.2 Treatment of Solvent Wastes

Waste solvent production occurs during the solvent wash of mixing tanks, caustic wash emulsions, steam cleaning of tanks and solvent wash of mixing equipment, pumps and machine parts. Solvent which is used for equipment cleaning consists of cleaning oils (varsols) for wet paint or methylene chloride for dry paint removal. The oils are reused until they are highly contaminated. At one location the oils are mixed with absorbants and packaged in metal barrels and disposed to landfill (the volume is less than 0.25 m^3/yr). Other plants maintain a stock of absorbants for use during spill cleanup. The volumes of such waste are small, not recorded and disposed along with general refuse to landfill. Plants which produce asphaltic coatings generally have no waste products as the lower grades of coatings can accept a wide range of waste materials

TABLE 6 ESTIMATED ANNUAL VOLUMES OF LATEX WASH WATER DISCHARGED TO SANITARY SEWAGE TREATMENT PLANT COLLECTION SYSTEMS

SEWAGE TREATMENT PLANT	NUMBER OF COMPANIES*	VOLUME OF WASTE WATER m^3/yr	SOLIDS (max. 3.0-6.0 %) m^3/yr
Annacis Island	9	326	9.8 - 19.6
Iona Island	3	< 200 (E)	6.0 - 12.0
Lulu Island	5	350 (E)	10.5 - 21.0
Lions Gate	2	45 (E)	1.4 - 2.7
Langley	1	6 (E)	0.2 - 0.4
Capital Regional District	1	3.	0.09 - 0.18
TOTAL	21	930 (E)	28 - 56

*Note: Includes only plants producing finished product. Not all companies discharge latex wastes and therefore do not contribute to this table.

(E) - Estimated based on best available data, range is 615-1000 m^3/y.

without compromising quality standards. Residuals such as tank scrapings, tank and barrel bottoms can be cleaned from the containers using a steam heat recovery system. Empty barrels are inverted on a steam heated rack (see Figure 1) where the heat softens the contents which flow to a sump and are pumped to a holding tank for reuse. Certain low grade oils are collected for use as road binder sprays which pre-oil the road bed dusts prior to the laying of asphalt pavement. Of the companies surveyed 11 indicated that solvent wastes were disposed through recycle, 9 gave insufficient information but are expected to recycle, 1 recycled by distillation and reuse of sludge and distillate, 1 combined oil with absorbant for landfill disposal and 2 did not use solvents as oils.

Most companies which recycle oils collect waste oil supplies until sufficient volume is stored for the production of exterior oil based wood stains and metal primers. Currently there is no designated secure landfill in British Columbia and contaminated oils which are classified as special wastes must be sent to the USA for disposal. Disposal fees range from $75.00-$200.00/barrel or higher and economic factors determine the fate of waste oil. Currently only one plant has a waste oil recovery still and it is being refitted for solvent distillation to handle its own waste production. Some plants sell waste oil to recyclers which blend them into low grade boiler fuels. These fuels are used in steam boilers for heat and power generation. Certain grades are sold for shipping fuel which can only be used once the ships are on the high seas. These fuels include waste oil and high sulfur bunker fuels from oil refineries. A significant number of paint companies are stock piling wastes in anticipation of a special waste site being established in B.C. These wastes are being held indefinately until either a site becomes available or storage space becomes a premium.

Companies may also delay the shipment of wastes to the USA due to the high cost and fear that they may become liable for cleanup costs if the wastes are not handled properly (13). Recycle of a large fraction of the oil based wastes produced is possible after the solids are settled out. The current high cost of disposal and lack of a regional facility encourages recycle into wood stain and metal primer. The stains are formulated

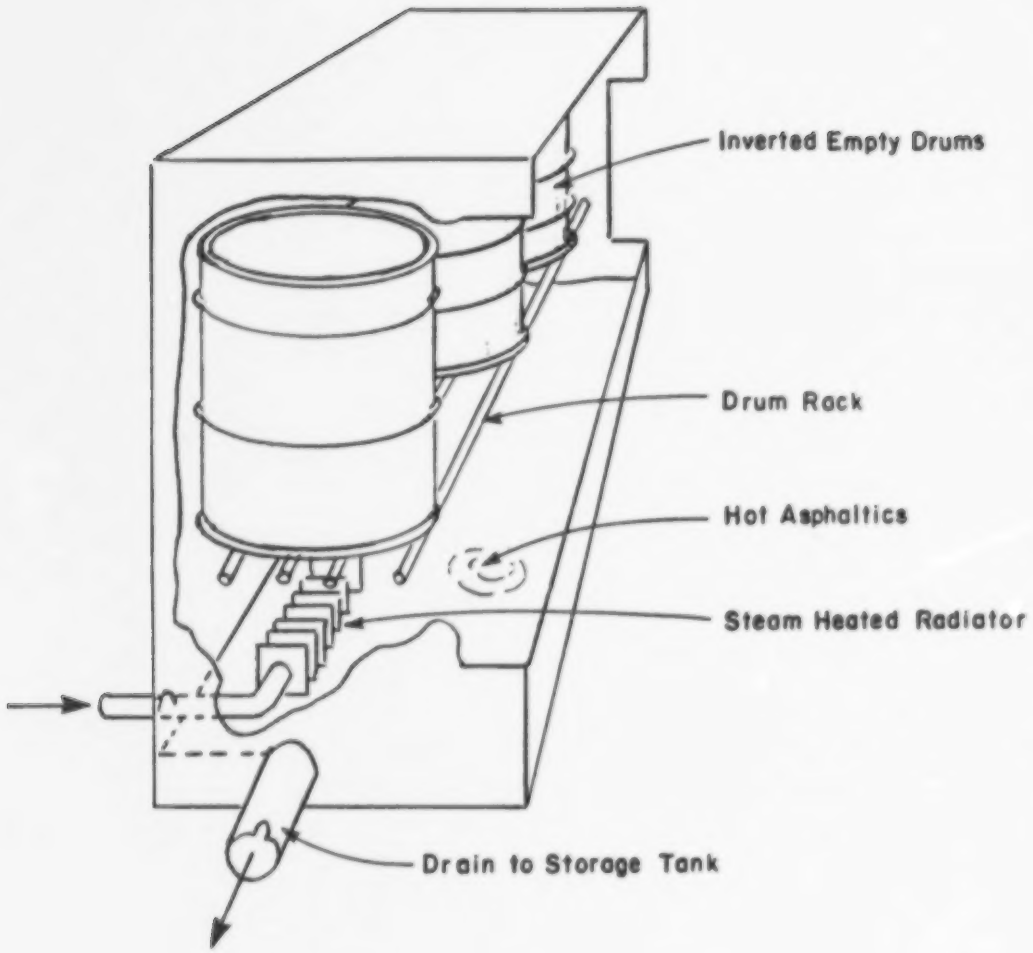


FIGURE 1 STEAM HEATED ASPHALT BARREL CLEANING SYSTEM

with waste oils and sludges as the base stock and are diluted with mineral spirits. The paint producers do not gain a significant profit from this kind of production. The price of the recycled stains and primers are from $4.00 to $8.00 per 4 l which is designed to cover production costs such as power, labour, packaging and marketing. The increased management effort, depreciation of equipment and low profit margin would favour treatment and disposal to landfill if disposal costs were lower.

6.3 Miscellaneous and Special Wastes

Miscellaneous wastes include general packaging wastes such as cardboard, wood, plastic and paper wraps etc. Included in this waste are empty cans up to 20 l size which have contained pigments and additives. These cans contain small amounts of residual pigment which contain a wide variety of metallic and organic compounds. The quantity of the pigment is not determined and is included with the estimated 4 800 m^3 of solid waste produced by these plants.

Special wastes include spoiled batches such as paints and coatings which do not meet quality or performance specifications and cannot be recycled or corrected. Problems with formulations or contamination can result in a product recall. Recalls of up to 568 m^3 (125 000 gallons) which required secure landfill disposal have occurred. Disposal costs for such a recall could be from $200,000.00 to $270,000.00 or more depending on the contents. These high costs are spread over several years by onsite storage with periodic disposal in 18 m^3 to 20 m^3 batches. There is no way to predict such volumes of waste except to add an additional factor to the average annual waste production. The current inventory of special wastes stored onsite for reuse (if cost effective) or disposal is estimated at 178 m^3. The cost of disposal of this waste at current prices would be $490-$750 m^3 ($427,550.00-$654,400.00). The disposal costs are a major concern to the paint manufacturers who would prefer to have a Regulated Provincial disposal facility to: 1) Lower costs; 2) reduce liabilities which might be incurred if foreign facilities were used; 3) ensure that wastes are properly disposed of; 4) relieve concerns that transborder shipment could be stopped on short notice.

7.0 SPILL PREVENTION AND WASTE REDUCTION TECHNIQUES OBSERVED AT PAINT AND COATINGS PLANTS

There were a number of safety features for the protection of workers and the environment and waste reduction techniques which were observed at various plants in B.C. They are noted as follows.

7.1 Dry Mixing Tank Cleanup Methods

Cleaning of mixing tanks is required periodically to remove scale buildup of old paint. (This can be avoided if the tanks are cleaned after every production day, which was done at one location.) Solvent or caustic soaks loosen or partially dissolve the scale on tanks and can be reused several times before disposal is required. Some companies limit the volume of waste and eliminate handling of liquids by using dry cleanup techniques. A metal chisel is shaped to the curvature of the tank and using an air powered hammer the scale can be chipped off the tank, usually in less time than is required for a soaking method. This eliminates the use of solvents and produces only solid wastes. These wastes are packaged in metal drums and disposed to a designated landfill. Most plants use specific tanks for certain blends of paint to prevent contamination and therefore the chipped paint can be segregated, minimizing the volume which requires special disposal due to preservatives or heavy metal content.

7.2 Sprinkler Systems and Fused Valves

Most paint plants had fire sprinkler systems in the production and/or storage area of the plants. These are usually required by insurance underwriters and building fire safety codes in the municipalities.

Several facilities were constructed with explosion systems which required that certain outside walls be designed to disintegrate outward after a specific interior air pressure is exceeded. The wall panelling is connected with wiring to reduce or prevent extensive scattering of debris.

Fuse protected valves were used on flexible product transfer hosing connected to metal piping. The valves are spring loaded and restrained in the open position by a wire connected to a metallic heat sensitive fuse (see Figure 2). In the event of a fire the fuse would melt at a temperature of 65°C (150°F) and shut the line restricting the potential volume of flammable liquid spillage to the contents of the flexible hose.

7.3 Elevated Floor Drains

Elevated floor drains were also used on the production floors of plants to prevent accidental discharge of spilled wastes or discourage workers from dumping wastes into drains which were not on treatment systems. The level of the drain pipe above the floor is sufficient to contain the volume of the paint or resin tanks contained in the interior production area. The drains were used for the discharge of uncontaminated cooling water from blending mills. Some companies have sealed floor drains with plugs to prevent accidental or intentional unauthorized discharges (see Figure 3).

At some facilities there was a noticeable lack of minor spill containment. This resulted in dirty floors and wastage of raw materials. Problem areas were at raw material storage racks where barrels were stored in horizontal positions with spring loaded or screw spigots. These were prone to leakage. Facilities with good control measures would underlay racks with cardboard which acted as secondary absorbants. The placement of empty 4 l cans or rectangular floor trays would catch the drippings from these barrels (see Figure 4). Absorbant materials and mops were stored at strategic places for immediate cleanup should a spill occur. In most cases these simple control measures were sufficient to reduce spillage and subsequent fume production. In plants where management stressed clean work procedures the production of wastes and loss of raw materials was reduced.

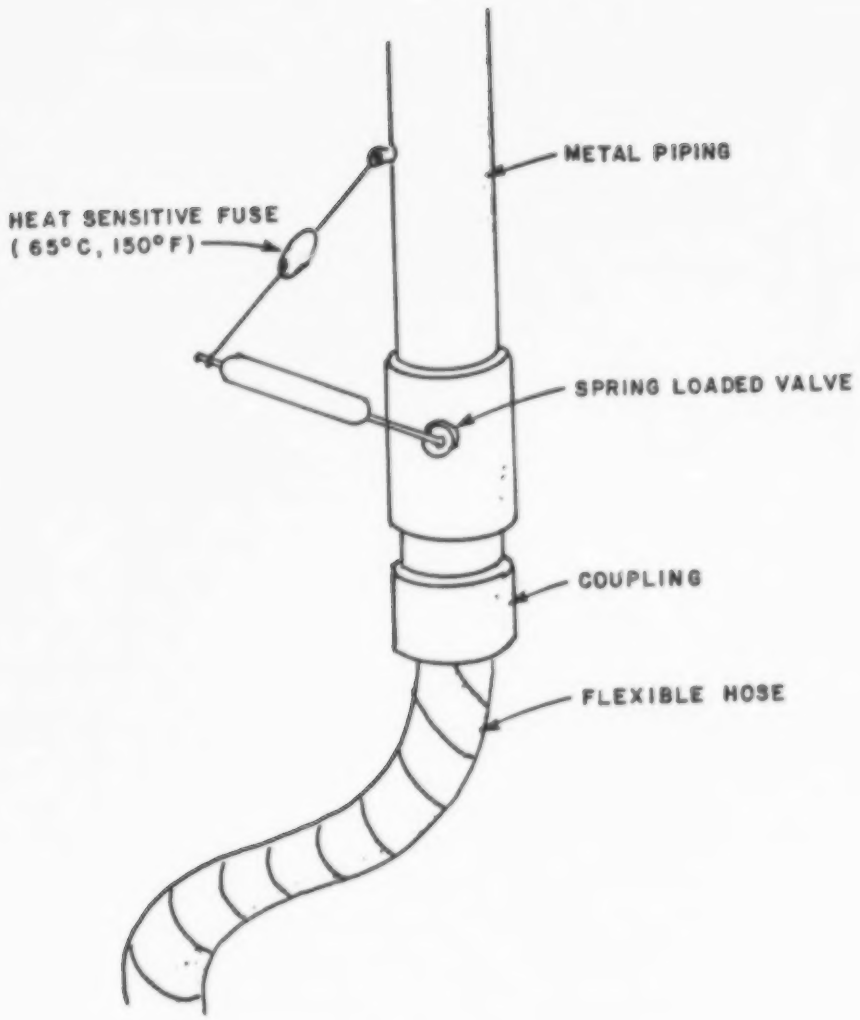


FIGURE 2 AUTOMATIC PRODUCT FLOW AND SPILL CONTROL BY HEAT SENSITIVE SPRING LOADED VALVE

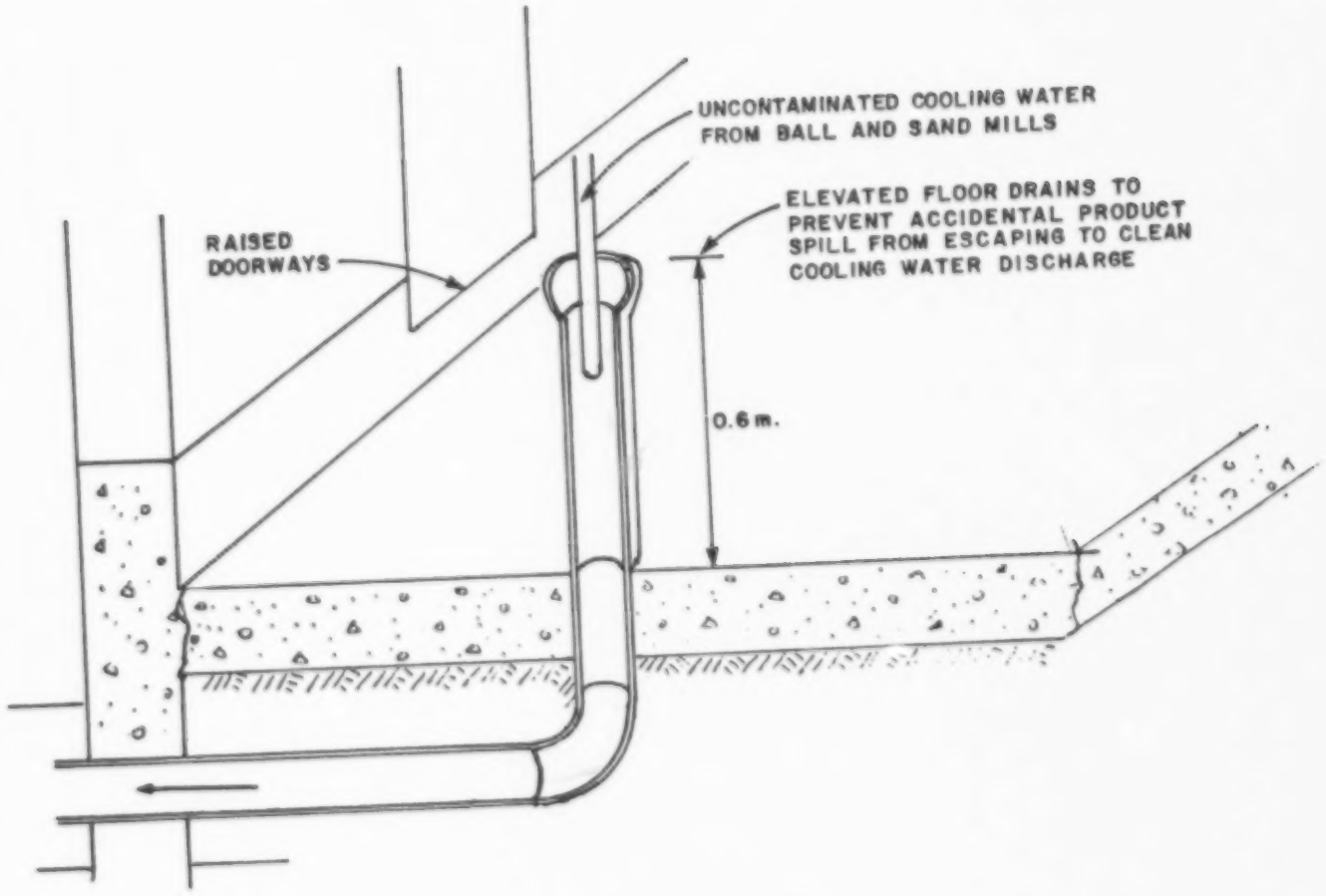


FIGURE 3 SPILL CONTAINMENT WITHIN PRODUCTION BUILDING BY USING RAISED FLOOR DRAINS AND DOORWAYS

7.4 Spill Retention Sills and Drip Collection Trays

Spill containment measures observed included raised sills on mezzanine production floors. The sills were 10 cm to 12 cm high around the perimeter of the mezzanine and would contain spills from tanks or additive barrels (see Figures 4 and 5). Floor drains were located at stairwell exits and connected to sumps or wastewater tanks where recovery and recycle was possible. Maintenance of a clean floor would aid in recycle potential. The proper containment of spills prevents contamination of other equipment which workers must handle and reduces the surface area of liquid which is subject to evaporation of solvents. One plant used wood chip board as production mezanine flooring. Such flooring would absorb the spilled resin and make cleanup difficult if not impossible. The floor becomes a source of recontamination through evaporation and dust production as it was subject to wear. Sealing of the floor is difficult and leakage of resins through the floor onto lower work areas was observed (14). This can be prevented by using cement or metal flooring which can be washed and is impervious to solutions and resistant to wear.

7.5 Raw Material Storage Areas

Powdered raw materials such as fillers, pigments, fungicides and toxic materials are sources of fugitive dust. These materials are often shipped in bags or cardboard barrels which are scrapped by compression and disposal to landfill. The crushing process can generate a significant amount of dust and several techniques were used to control this. At one plant toxic materials such as lead pigments, mercurial fungicides, pentachloro and tetrachlorophenols were stored in a fenced, locked containment area. All measurements of these materials were performed in the containment area under a vaccuum dust collection hood which was connected to a central dust collection system. The weighed materials were then transported to the mixing stations. Crushing of the empty containers can generate considerable volumes of dust which can contaminate floor or

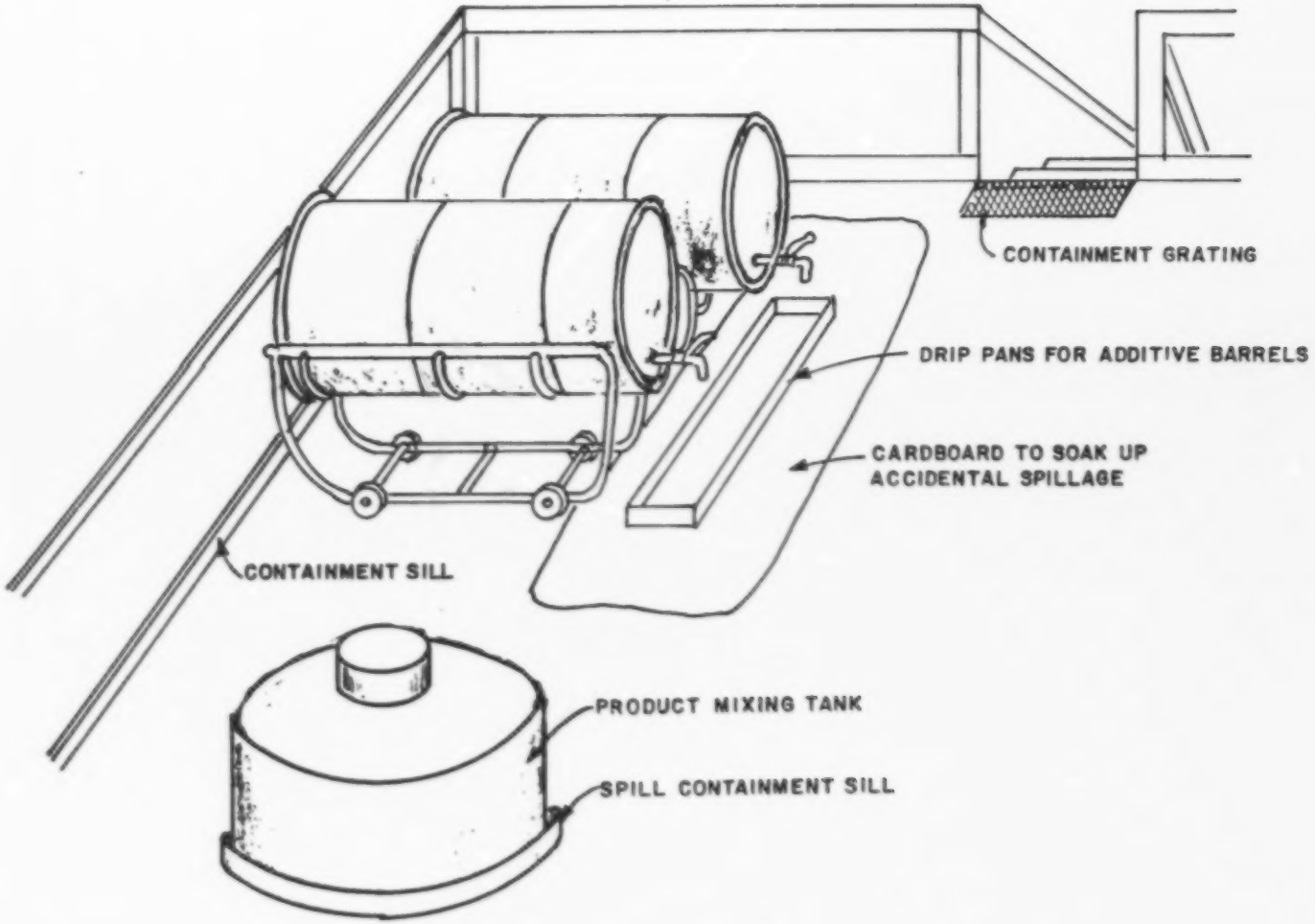


FIGURE 4 DRIP AND SPILL CONTAINMENT ON RAISED PRODUCTION MEZZANINE

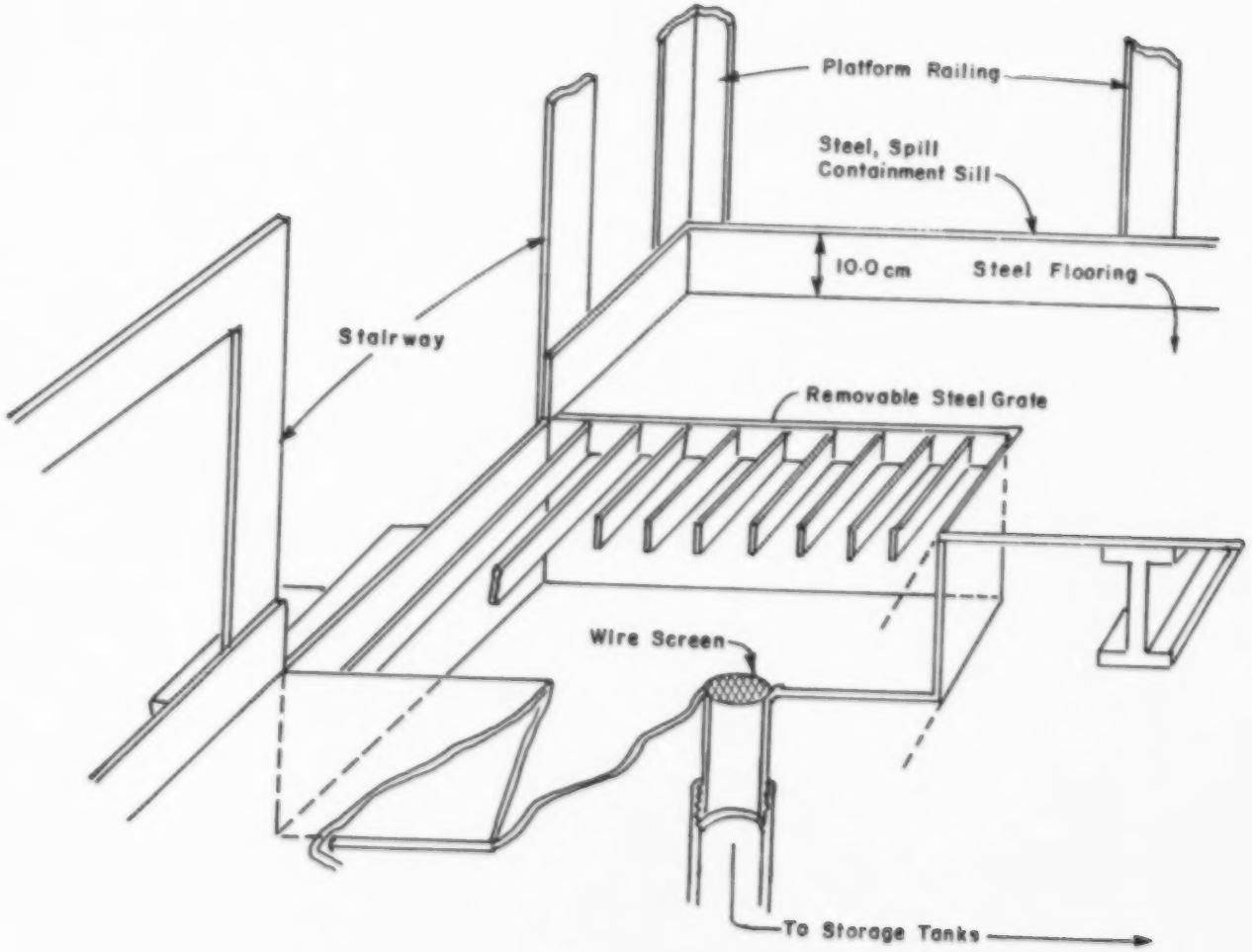


FIGURE 5 SPILL CONTROL AT MEZZANINE STAIRWELL

parking lot areas. In exterior areas a prolonged build-up can create a shock load of contaminants to a storm sewer system during a sudden rainfall. This has been overcome by one firm by moving the crusher indoors and connecting it to a baghouse filter system. The bags can be sorted for those which contain innocuous materials such as fillers which can be compressed, baled and sold to paper recyclers or firms which manufacture shredded insulation from waste paper.

7.6 Liquid Raw Material and Product Storage Tanks

Plants which do not protect above ground storage tanks with berms run the risk of high product loss and severe costs for cleanup and possible prosecution by civil or governmental agencies. A recent raw materials spill has cost in excess of $250,000.00 for cleanup costs, chemical monitoring, consultant and legal fees. This does not include legal penalties or sales losses due to adverse publicity. Safety precautions and containment measures observed at some facilities to reduce risks include:

1) Ensuring the structural integrity of storage tanks by regular (in some cases daily) inspections for leak detection, deterioration from corrosion and proper operation of level indicators.

2) Design and construction of earthern or cement berms which are able to contain the liquid contents of the tanks which they protect.

3) Tank designs which have inflow hatches located on the top of the tank and no valves or tank drains located on the bottom of tanks which can be tampered with by unauthorized persons.

4) The tanks are connected via piping to pumps and header systems which are located in the production areas. Exterior valves which may be used for tank drainage are locked.

Tank farms and work yards at several locations are surrounded by fences topped with barbed wires to hamper or prevent unauthorized access.

Some plants use activated charcoal filtering systems for air/fume discharges from storage and mixing tanks on the production floors. This reduces air pollution and odour problems at the plant site.

None of the plants visited had leak detection devices or groundwater detection devices or groundwater monitoring wells on underground storage tanks. Only one facility regularly inspected its underground tanks for corrosion.

Companies should examine their production and storage facilities for possible routes of any raw materials or finished products to the environment and take corrective measures where necessary.

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APPENDIX I

Environmental Contaminants Act

PRIORITY AND CANDIDATE CHEMICALS

June 9, 1984

This fifth review of the List of Priority and Candidate Chemicals is published as an indication of the substances that are of particular interest to the two Departments for the gathering and analysis of information. The mere mention of chemicals in this List does not mean that they will be proposed for regulation. Rather, this List is intended as information for the public, industry, academia, provincial governments and other federal government departments so that they may be aware of the information gathering activities which are being carried out by the Department of the Environment and the Department of National Health and Welfare. Interested parties who have information which may be of assistance in evaluating the potential of a chemical to adversely affect the environment or human health are invited to communicate this information to either of the officials identified at the end of this notice.

The priority and candidate chemicals lists comprise, principally, chemical substances that are imported into Canada or manufactured or processed in this country. Chemicals that are used solely as drugs, food additives or pest control products may not be included in this List if they are already scrutinized or controlled under other federal legislation. Chemicals that have been included in the List may subsequently be removed by adding the substance to the Schedule to the act for regulation, or by a decision that the substance does not pose a threat to human health or the environment and, therefore, does not warrant regulation under the Environment Contaminants Act. In the latter case, for some substances, the two departments may still have a continuing concern under other federal mandates. Those substances that appeared on the previous (1982) version of the List and that are not included in this version are mentioned in a separate section of this notice with a brief explanation of why they have been removed from the List.

The same three criteria announced in the December 1, 1979, *Canada Gazette* notice that pertain to the hazards posed by a chemical substance to human health or the environment were applied to the selection of chemicals for this version of the List. These criteria encompass the several properties of a chemical substance, e.g., carcinogenicity, mutagenicity, reproductive and other forms of toxicity, volatility, solubility, routes of entry into the environment, dispersion and distribution throughout the environment, nature of transformation products, impurities, persistence, accumulation in tissues and amounts imported, manufactured or processed. The three criteria are:

(1) *Toxic effects criterion.* Evaluation of scientific data leads to the conclusion that the chemical substance could cause or causes adverse effects on human health or the environment.

(2) *Persistence criterion.* Evaluation of scientific data leads to the conclusion that the chemical substance accumulates or could accumulate to significant concentrations in air, water, soil, sediment or tissue.

(3) *Quantity and use criterion.* Evaluation of available data on the importation, manufacture, processing or use of a chemical substance leads to the conclusion that the substance is in commerce and could enter or has entered the environment in significant quantities.

LIST OF PRIORITY CHEMICALS

The current List of Priority Chemicals, which supercedes previous lists, is presented below with a description of each category.

Category I: Those substances for which regulations or specific control strategies are being developed under the *Environmental Contaminants Act.*

Polychlorinated Biphenyls (PCBs)

Chlorobiphenyl Regulations No. 1 under the *Environmental Contaminants Act* came into effect in 1977, restricting use of PCBs in new non-electrical equipment. An amendment which extended the prohibition to new electrical equipment and which further restricted the use of PCBs in existing equipment came into effect in July 1980. Two further regulations on PCBs were proposed in the *Canada Gazette Part I* on January 21, 1984. Proposed Chlorobiphenyl Regulations No. 2 (Product) will control commercial activities involving products designed to use PCBs that contain more than 50 parts per million of PCBs. Proposed Chlorobiphenyl Regulations No. 3 (Release) will establish limits on quantities and concentrations of PCBs that may be wilfully released into the environment. Also, a strategy is being developed to achieve an orderly and accelerated phase-out of PCBs currently in use.

Chlorofluorocarbons (CFCs)

A regulation under the *Environmental Contaminants Act,* restricting the use of chlorofluorocarbons as aerosol propellants in hair sprays, underarm deodorants and antiperspirants came into effect on May 1, 1980. An amendment to this regulation, extending the restriction to all deodorants, came into effect on May 7, 1981. The need for controls on the non-aerosol uses of CFCs is being reviewed.

Category II: Those substances which are being investigated to determine the nature and the extent of the danger to human health or the environment and the appropriate means to alleviate that danger.

Chlorobenzenes

Many of the chlorinated benzenes have been identified in the tissue of fish or herring gulls from the Great Lakes, indicating the presence of these chemicals in the environment and their persistence and accumulation. The use of mixtures of tri- and tetrachlorobenzene as replacements for PCBs could lead to an increase in their consumption and thus an increase in environmental exposure. Hexachlorobenzene (HCB), a waste-product of several industrial processes, is persistent and can be bioaccumulated. Review of the national situation shows that HCB occurs throughout the environment. There is recent evidence that some chlorobenzenes are toxic, especially HCB, and while environmental levels are not of immediate concern, there is a need to investigate the pathways of exposure through the environment and the potential effects on health and environmental biota.

Phthalic Acid Esters

Large quantities of phthalic acid esters are used in Canada and are released into the environment during processing and as a result of the use and disposal of products containing them. Their greatest use is as plasticizers although they have numerous other uses such as replacement for polychlorinated biphenyls. Several, including diethyl phthalate, dibutyl phthalate (DBP), and di-(2-ethylhexyl) phthalate (DEHP), have been studied in detail. Residues of DEHP and DBP in air, sediment, water, fish, and herring gull eggs have been detected, indicating their presence in the environment. DEHP has been reported to be carcinogenic in the rat and the significance of this with respect to human health has yet to be determined. A number of phthalates are currently undergoing long-term toxicological testing. Sublethal toxicity testing and environmental measurements for the aquatic medium are needed.

Category III: Those substances which may pose a significant danger to health or the environment and about which further detailed study or information (for example toxicology, amounts used or concentrations in the environment) is necessary.

Chlorinated Paraffins (CAS No. 63449-39-8)

For the purposes of this List, chlorinated paraffins are defined as complex mixtures of compounds having more than 10 carbon atoms and 35-70% chlorine by weight. These chemicals are produced in large quantities and are used as lubricants and cutting oil additives, plasticizers and, in particular, as flame retardants. They are considered to be stable and to have a high potential to contaminate the environment. There is a paucity of data concerning the concentrations of these chemicals in environmental media and their toxicity, although some of these substances are currently undergoing tests for mammalian and aquatic toxicity.

Chloroethanes

1,2-Dichloroethane, 1,1,1-trichloroethane and 1,1,2,2-tetrachloroethane are produced and used in high volume; their loss into the environment and their potential toxic and environmental effects are cause for concern. Information is being collected on the use patterns of these three chemicals. Data are needed on environmental levels and the possible resultant effects on humans and other organisms.

Chloroethylenes

Trichloroethylene and tetrachloroethylene exhibit a variety of toxic effects and are employed in large quantities for essentially dispersive uses such as cleaning solvents. Information is being collected on the use patterns of these chemicals. Data are needed on environmental levels and the possible resultant effects on humans and other organisms.

Chloromethanes

Carbon tetrachloride, chloroform and dichloromethane are used in high volume and have high potential for release to the environment. They have been observed in Great Lakes waters and some have been found in finished drinking water as a result of environmental contamination and the use of chlorine as a disinfection agent. There is concern over the chronic toxicity of these compounds, and the tri- and tetrachloromethanes have been reported to be carcinogenic based on animal studies. Information is being collected on the use patterns of these chemicals. Data are needed on environmental levels and the possible resultant effects on humans and other organisms.

Organotins

Organotin compounds are incorporated (as antioxidants, stabilizers, biocides, etc.) into a variety of synthetic materials. The widespread use of these substances, coupled with their stable chemical nature suggests that organotins may be widely distributed and persistent; these aspects are under investigation. A brief review of these chemicals ("Organotins in the Canadian Environment – A Synopsis", Environment Canada Report EPS 3-EC-82-1, 1982) has been published which identified the lack of data on environmental concentrations and ecotoxicity.

LIST OF CANDIDATE CHEMICALS

The List of Candidate Chemicals includes chemicals which may pose environmental contamination problems and for which the concern is insufficient to warrant placement in the List of Priority Chemicals. For some Candidate Chemicals the available data are inadequate and must be supplemented where appropriate by information on commercial use-patterns, biological effects, other properties, or environmental occurrences. This information will be sought, but at a lower level of effort that for Priority Chemicals. As the information is accumulated, some of the substances may warrant more detailed study and be placed on the List of Priority Chemicals or may not warrant continued investigation and be deleted from the List of Candidate Chemicals.

Aromatic Amines

For the purpose of this List, aromatic amines comprise:

(a) diphenylamine and derivatives

(b) aminobiphenyls and derivatives
(c) aniline, its methyl or ethyl derivatives whether these groups are substituents on carbon or nitrogen, and those derivatives of all these compounds that carry chloro, bromo or nitro substituents in the ring.

Some of these chemicals are produced in large quantities and are put to a variety of uses including dyes, antioxidants, explosives, plastics, stabilizers, and precursors for the manufacture of herbicides and fungicides. Some have been detected in the Great Lakes and some are believed to be carcinogenic or otherwise toxic.

Ethylenethiourea (2-imidazolidinethione)
This chemical is used in the rubber, dyestuff and pharmaceutical industries. It also occurs as a degradation product of ethylene bis-dithiocarbamate fungicides which are used in agriculture. Literature reports indicate this chemical is mutagenic and has produced tumorigenic and teratological effects in laboratory animals.

Halogenated Diphenyl Ethers
These compounds are used principally as flame retardants. Some are persistent and in laboratory studies have been found to accumulate in fish. Chlorodiphenyl ethers have been detected in sediments.

Halogenated Toluenes
Almost all the chemicals in this class are used as intermediates; some are used as solvents. Specialized product uses include frothing agents, gasoline gum inhibitors and flame retardants. Tetra- and pentachlorotoluene have been found in fish from the Great Lakes.

Nitrophenols
For the purpose of this List, nitrophenols comprise those chemicals which contain one or more nitro substituents on the aromatic ring of a mono- or polyhydroxybenzene. These compounds are widely used as intermediates in the chemical industry. They are moderately persistent in the environment and are reported to be toxic.

Organophosphorus Compounds
For the purpose of this List, organophosphorus compounds comprise:
(a) phosphines
(b) phosphine oxides and derivatives
(c) phosphinic acids and derivatives
(d) phosphonic acids and derivatives
(e) phosphites and derivatives
(f) phosphates and derivatives
(g) phosphoranes and derivatives
Some of these compounds are used as plasticizers, flame retardants, lubricants and fuel additives. Many are very stable and may persist in the environment. The triarylphosphates were included in the preceding List of Candidate Chemicals and have been retained on this List as part of this group of chemicals.

DELETIONS FROM THE LIST OF PRIORITY CHEMICALS

The following chemicals were on the previous (1982) List and do not appear on this version for the reasons indicated below.

Cadmium
Investigation by the two Departments has shown that at the present time there is insufficient evidence to warrrant the addition of cadmium to the Schedule to the Act for regulation. Cadmium and its compounds continue to be of concern to other high-priority programs of both Departments which are designed to control specific contamination problems.
Details of the investigation which served as the basis for deleting cadmium from the List of Priority Chemicals are contained in the publication entitled "Environmental Contaminants Act: Hazard Assessment Report on Cadmium" (December 1983); copies of this report may be obtained by contacting either of the officials identified at the end of this notice.

Chlorophenols
Commercial formulations of these compounds have been of concern because of their widespread use, toxicity and the presence of various impurities such as chlorodibenzodioxins and chlorodibenzofurans. These compounds have been under review for some time now and have been the subject of three reports ("Chlorophenols and Their Impurities in the Canadian Environment", Environment Canada Report EPS 3-EC-81-2, 1981; "Chlorophenols and Their Impurities in the Canadian Environment; 1983 Supplement", Environment Canada Report EPS 3-EP-84-3; "Chlorophenols and Their Impurities: A Health Hazard Evaluation" Health and Welfare Canada Report 84-EHD-110 (in press)).
Chlorodibenzodioxins have been the subject of two separate reports released in December 1983 and entitled "Report of the Ministers' Expert Advisory Committee on Dioxins" and "Dioxins in Canada: The Federal Approach". Both documents provide an overview of the potential problems posed by chlorodibenzodioxins and enumerate actions to be taken by the federal government, often in collaboration with provincial agencies, to reduce the exposure of Canadians to dioxins.
Some of the major uses of chlorophenols are controlled by the *Pest Control Products Act* administered by Agriculture Canada, and recent changes in the permitted uses will reduce the potential for releases into the environment. Another change has set lower limits for the dioxin

content of some chlorophenols. Furthermore, measures have been initiated to implement a code of good practice for the use of chlorophenols in wood treatment and preservation which should further assist in reducing human exposure and releases to the environment.

With the measures which have been taken and are proposed, the two Departments have concluded that there is not sufficient cause to warrant the addition of chlorophenols to the Schedule to the Act for regulation at the present time. Chlorophenols and their contaminants will continue to be of concern to other high priority programs of both Departments.

Dodecachloropentacyclooctadecadiene (CAS No. 13560-89-9) and Hexachlorobutadiene (HCBD)

Evaluation of the commercial use patterns and data on environmental concentrations led to the conclusion that the potential exposure of humans and the ecosystem was not sufficient to merit further in-depth investigation at this time.

Anyone who has comments or seeks clarification regarding the present document, or has pertinent information on these chemical substances, should contact either of the following officials.

J.E. BRYDON
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Environmental Protection Programs Directorate
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Ottawa, Ontario K1A 1C8

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APPENDIX II

Environmental Protection Service

STUDY OF THE CHARACTERIZATION OF WASTES AND DISCHARGES FROM SELECTED ORGANIC CHEMICAL PLANTS

DRAFT REPORT

SRCL 3479

MARCH 1985

SIGMA RESOURCE CONSULTANTS LTD

CONTENTS

1. SUMMARY

2. APPROACH

   2.1 GENERAL
   2.2 SAMPLE COLLECTION APPROACH
   2.3 ANALYTICAL APPROACH

3. PLANT A

   3.1 PROCESS DESCRIPTION - PLANT A

   3.2 SAMPLE DESCRIPTIONS - PLANT A

      3.2.1 Latex Effluent
      3.2.2 Latex Sludge
      3.2.3 Spent Solvent Sludge
      3.2.4 Paint Skins

   3.3 PRIORITY CHEMICALS - PLANT A

      3.3.1 Phthalic Acid Esters
      3.3.2 Chlorinated Phenols
      3.3.3 Triaryl Phophates
      3.3.4 Organotins

   3.4 MAJOR WASTE COMPONENTS - PLANT A

      3.4.1 Latex Resin
      3.4.2 Alkyd Resin
      3.4.3 Pigments and Pigment Extenders
      3.4.4 Surfactants
      3.4.5 Plasticizers - Phthalic Acid Esters
      3.4.6 Plasticizers - Fatty Acids
      3.4.7 Preservatives
      3.4.8 Solvents

         3.4.8.1 Latex Effluent
         3.4.8.2 Spent Solvent Sludge

6. PLANT D

   6.1 PROCESS DESCRIPTION

6.2 SAMPLE DESCRIPTIONS

6.2.1 Combined Effluent
6.2.2 Tank Washing
6.2.3 Baghouse Dust

6.3 PRIORITY CHEMICALS - PLANT

6.3.1 Phthalic Acid Esters
6.3.2 Chlorinated Phenols
6.3.3 Triaryl Phosphate
6.3.4 Organotin

6.4 MAJOR COMPONENTS

6.4.1 Solvents

8. ANALYTICAL RESULTS

9. VOLUMETRIC AND MASS LOADING

APPENDICES

LIST OF ABBREVIATIONS AND DEFINITIONS

2. APPROACH

2.1 GENERAL

The general approach to the study involved process review, site visits, sample site selection, sample collection, conventional anaylses, organic parameter analytical schedule preparation, organic analyses and finally analytical results review and report preparation. The objective of the study was to generate data on types and quantities of organic chemicals present in the discharges from the selected plants with special emphasis on Priority and Candidate Chemicals identified by the Environmental Contaminants Act.

2.2 SAMPLE COLLECTION APPROACH

Wastewater and sludge samples were collected at each plant with the intent of characterizing and quantifying all major waste components and priority chemicals. Prior to the site visits, internal EPS plant dossiers were reviewed to provide background information on the manufacturing process involved, plus related wastewater and sludge production at each subject plant. Plant visits then involved review of manufacturing processes and waste generation with company representatives so as to determine waste sample collection sites, flowrates and discharge frequency of all wastewater and solid discharges. The major emphasis of sample collection was in obtaining samples which were as representative as possible. All samples except final effluent at Plant D were grab. The final liquid effluent at Plants A & E were collected in holding tanks, mixed and then discharged on a batch basis. These effluent grab sampmles were therefore representative of a significant number of days plant operation. Raw liquid effluent from Plant B discharges to a mixed 14 day equalization pond prior to treatment in an activated sludge unit. Therefore the intermediate sample (Table 1-2, 3-2) would be representative of a reasonable number of days of operation at Plant B and obviously the discharge from the activated sludge unit would be fairly representative of treated effluent. The final effluent at Plant C is excess cooling water bled from a cooling water circuit. A forced air cooling tower is utilized to reduce water temperature prior to recycle. Excess

cooling water would represent only a small percentage of the recycle flowrate, therefore the effluent sample would be representative of several weeks of operation. Plant D is a relatively small paint manufacturer. Waste discharges at this plant are highly dependent on the type of paint being manufactured at any given time. Recycle of solvent and water washes can virtually eliminate a discharge. Therefore a composite sample was collected during a period when some discharge was expected. This sample therefore did not represent "typical" or average conditions. All sludge and solids samples collected during the study were grabs due to the extreme difficulty involved in obtaining representative sludge samples. However, sludge samples AS-2 and CS-14 would be relatively represented since they were mixed and accumulated over a reasonable time period.

2.3 ANALYTICAL APPROACH

The twenty samples obtained from the plants consisted of two major types: liquid effluents and solid wastes. The solid wastes could be further subdivided into sludges (process and treatment wastes) and dry solids (baghouse and cyclone collection dusts). Due to the different types of plants under study; that is type of product produced and raw materials used, the samples collected were very diverse.

A number of factors were taken into consideration in choosing an approach to the analyses of the samples for organic parameters. Firstly, information obtained from the plant dossiers supplied by the Scientific Authority and information from the manufacturers, was used to determine the raw materials and type of process utilized. This, in conjunction with technical literature on production techniques allowed for some insight into the possible presence of some chemical compounds.

Secondly, the Priority and Candidate Chemicals of the Environmental Contaminants Act were taken into consideration. Based on raw material usage, finished product and by-product production, the potential presence of the regulated compounds were examined.

Finally, general physical observation and conventional chemical analyses, as well as a "crude" organic extraction and analyses, yielded information on the chemical complexity of the various samples.

Taking into account all of the above, the analytical requirements with respect to the priority and candidate chemicals were defined. Many of the groups of chemicals defined in the Act were eliminated by their absence from use in production and the impossibility involved with their production as by-products. These include compounds or compound groups such as polychlorinated biphenyls (PCBS), chlorofluorocarbons, chlorobenzenes, ethylenethioures and halogenated toluenes and diphenyl ethers.

A number of groups were targeted for specific analyses, including phthalate acid esters, chlorinated phenols, tri-aryl phosphates, and solvents. The analyses for these groups were optimized and a select list of parameters within each group were specifically sought.

Due to the nature of some of the raw materials consumed and the types of products produced, it was identified that many of the organic compounds present would not be amenable to analyses by the techniques selected. Long chain cellulose compounds used as thickeners and fillers as well as polymers would be prime examples. Many of these compounds are considered innocuous relative to the compounds of interest, therefore the need for identifications or quantitation of these compounds was a low priority.

The extraction of the samples for organic parameters generally followed the protocol of the U S E.P.A. priority pollutant analysis. Extractions of the liquid samples were carried out on a total extractable basis. This was achieved using liquid - liquid extractions under both acidic and basic pH conditions. The solid waste samples were extracted in two ways: firstly on a total basis and secondly on a leachable or extractable basis using a modification of the BC Ministry of Environment Special Waste Extraction Procedure (SWEP). This leacheate procedure is used to simulate the effect of landfill conditions on solid waste.

Extractions are carried out on the dewatered portion of wet sludges, but directly on dry solids. A modification was made in the procedure to allow for certain important conventional parameters to be analyzed on the leacheate solution. The solutions generated from the SWEP test were then extracted on a total basis for the organic analyses. Details of the analytical methodology covering the extraction of liquid and solid wastes and the SWEP test are included as in Appendix A.

Based on the results of the conventional analyses, the "crude" extraction and analyses, and the gas chromatographic analysis of the acid and base-neutral fractions of the sample extracts, ten samples were selected for further analyses by gas chromatography/mass spectrometry (GC/MS). The criteria used was the complexity of the sample extracts and the number of "unknown" components present. Each set of sample extracts was subjected to a target search for certain classes of the U S E.P.A. organic priority pollutants. The PCB and pesticide fraction was omitted as discussed previously. This allowed for analysis for many compounds in the sample extracts which could not be economically achieved using conventional gas chromatography techniques. The extracts were also analyzed by searching the GC/MS spectral data generated through a library of spectra in order to facilitate identification of many of the major components. A threshold was set for each sample extract to enable this phase of the study to remain cost effective. Despite the extensiveness of the library of spectra it was expected that some of the components would remain unidentified.

Solvents were considered to be a major component of the liquid effluents and sludges and the leachate extractions. The analysis for solvents was carried out using a direct injection technique. This was found to have a distinct advantage over head space or extractable analyses as a number of factors, including temperature, partition coefficients and extraction solvent selection were eliminated.

3. PLANT A

3.1 PROCESS DESCRIPTION - PLANT A

Plant A manufactures a wide variety of alkyd and latex paints, stains, varnishes, lacquers, wood preservatives, metal primers and metal enamels. Manufacture involves the blending of paint resins, pigments, solvents and a wide variety of additives such as plasticizers, preservatives and colloids. A full discussion of paint formulation is beyond the scope of this report. Reference should be made to the general literature for technical information on the components of latex and alkyd paints.

All basic components of the paint formulations produced by Plant A are manufactured by others and stored on-site. Total annual production is approximately 2800 m^3 with solvent based coatings representing 55%, water based coatings at 25% and the remainder divided into varnishes, lacquers, paint thinner and cleaners. The processing area is divided into two main areas; one for latex paints (water based) and one for alkyd paints (solvent based). All alkyd blending tanks and equipment are cleaned with a solvent mixture containing xylene which is then collected after use and re-distilled in a waste solvent recovery still. Clean solvent is then recycled for paint production or clean-up. The "bottoms" from the solvent still are used in the production of metal primers and wood stains.

A "spent solvent sludge" accumulates in the portable waste solvent collection tanks. This material cannot be easily re-suspended for process through the solvent recovery system. Approximately 0.2 m^3 per month of "spent solvent sludge" is scraped from the solvent collection tanks and stored on site. Approximately 200 drums of this material are stored on site. Application has been made for shipment and disposal to a hazardous waste disposal site in the US.

The latex formulation equipment is washed with water which discharges via an open floor sewer system to an underground sump. Latex wash water is pumped from the sump to a flocculation tank (11 m^3). Once this tank is full, ammonium

hydroxide is added to adjust pH and alum is added to coagulate solids. After mixing is complete, solids are allowed to settle to the bottom of the tank as "latex sludge" and supernatant (treated latex wash water) is decanted off and discharged to the municipal sewer. Treated latex washwater (11 m^3) is batch discharged on average every two weeks, broken down into once a week during busy periods and every three weeks during slow periods. The "latex sludge" in the flocculation tank accumulates and is pumped to a separate sludge holding tank (18 m^3) once every five weeks on average. Approximately 16 m^3 of "latex sludge" is produced annually. Prior to final disposal, the collected latex sludge is thickened an additional 15% using alum and ammonium hydroxide. This thickened sludge is pumped into 45 gallon barrels, mixed with portland cement and allowed to harden. The sludge/cement ratio is approximately 4:1 on a w/w basis. Approximately 70 barrels are produced annually for disposal to local landfill. The cementing and disposal operation is carried out annually on a batch basis.

3.2 SAMPLE DESCRIPTIONS - PLANT A

A log of samples collected during this study is provided in Table 1. Detailed descriptions for each sample at Plant A are provided in the following sections.

3.2.1 Latex Effluent

This sample represents treated latex washwater generated from the latex (water based) production section of the Plant. The wastewater essentially consists of paint residues, in fact the samples had the appearance of dilute paint. Standard analytical characteristics as listed in Appendix B Table 1-1 indicate that samples collected were high in NFR, COD, turbidity, TOC, TN and ammonia.

The organic characteristics, as listed in Appendix B Table 4-1 indicate the sample has major concentrations of hydrocarbons and fatty acids plus minor amounts of acetone, ethanol, methanol, methyl ethyl ketone, xylene and ethylbenzene. The presence of the above compounds indicates that some cross-over is taking place from the alkyd system into the latex system.

3.2.2 Latex Sludge

This sample is essentially concentrated latex paint with a high TR, COD and oil and grease Appendix B (Table 2-1).

3.2.3 Spent Solvent Sludge

This sample consisted of a heavy clay-like material containing significant amounts of hydrocarbons and fatty acids. Standard analytical characteristics as listed in Appendix B Table 2-1 indicate that the sludge contains high levels of inorganic solids, CAOV and oil and grease.

3.2.4 Paint Skins

"Paint skins" is generated by weekly plant clean-up and consists of paint floor scrapings plus other general paper and plastic debris.

3.3 PRIORITY CHEMICALS - PLANT A

3.3.1 Phthalic Acid Esters

Diethyl, Di-n-butyl and Bis (2-ethyl Hexyl) phthalates were detected at concentrations an order of magnitude above detection limit. Butyl benzyl phthalate was also present but only slightly above detection limit. Dimethyl and di-n-octyl phthalate were below detection limits in all samples. These compounds are utilized in paint formulation as plasticizers to provide film flexibility.

The presence and concentration of a particular phthalate compound in paint wastes would be highly variable since a wide variety of plasticizers are utilized depending on the type of paint being manufactured.

3.3.2 Chlorinated Phenols

Tetrachlorophenol and pentachlorophenol were detected in all samples with the highest concentrations in the spent solvent sludge.

3.3.3 Triaryl Phosphates

Triphenyl, tricresyl and tri-butyl phosphate were all less than detection limit in the latex effluent.

3.3.4 Organotins

Analyses were not performed due to low levels of total tin observed in the latex effluent and sludges.

3.4 MAJOR WASTE COMPONENTS - PLANT A

The major components of the wastewater generated from Plant A originate from the manufacture of latex paint. These components fall into the general categories listed in Table 2, namely latex resins, alkyd resins, pigments, surfactants, plasticizers, preservatives, thickeners and solvents. These general categories are discussed below with reference to the analytical results. The component list in Table 2 is not intended to be comprehensive or to necessarily reflect the compounds utilized by Plant A.

3.4.1 Latex Resin

Latex resins are produced by polymerization of organic monomers. This type of compound cannot be analyzed for directly in wastewater but is evident from the general parameters, colour, turbidity, COD, TOC, TR and NFR. These resins are concentrated in the latex sludge, evident by the high COD and percent residue.

3.4.2 Alkyd Resin

Alkyd resins are produced by polymerization similar to latex but contain drying oils, aliphatic hydrocarbons, and other solvents. These compounds are at high concentrations in the spent solvent sludge and also appear in the latex effluent and sludge due to cross-over from the alkyd circuit.

TABLE 2

POTENTIAL WASTE COMPONENTS OF LATEX PAINT MANUFACTURE

Water	
Latex (Binder)	Polyvinyl acetate
	Ethyl acrylate
	Methyl methacrylate
	Ethyl hexyl acrylate
	Bibutyl maleate
	Polyvinyl chloride
Pigments	Titanium dioxide
	Zinc oxide
	Lead carbonate
Pigment Extenders	Barium Sulfate
	Calcium carbonate
	Aluminium silicate
	Silica dioxide
	Magnesium Silicate
	Mica
Surfactants	Alkyl sulfate
	Alkyl sulfonates
	Alkyl ethers
	Thioethers
	Glycols
	Octylphenoxy polyethoxy - ethanol

Coalescing Agents (Plasticizers)	di-N-butyl phthalate
	di-octyl phthalate
	tricresyl phosphate
	tributyl phosphate
	butyl carbitol acetate
	butyl cellosolve acetate
Fungicides & Preservatives	sodium pentachlorophenate
	phenyl mercury oleate
	sodium tetrachlorophenate
	tri-n-butyltin
	copper napththenate
	zinc napthenate
Protective Celloids & Thickeners	methyl cellulose
	carboxy methyl cellulose
	hydroxy ethyl cellulose
Solvents	ethylene glycol
	propylene glycol
	butyl cellosolve

3.4.3 Pigments and Pigment Extenders

The presence of pigments and extenders is indicated by the metal levels in both the effluent and sludges. Minor amounts of other metals not generally used in pigment could be due to impurities in the general pigment formulation. Metals present due to pigments include barium, cobalt, chromium, manganese, aluminum, lead, zinc, titanium, iron, silicon, calcium and magnesium.

3.4.4 Surfacants

Surfactants can be subdivided into wetting agents, emulsifiers, detergents and dispersing agents. All surfactants except the dispersing agents are organic compounds which would only be detectable by GC/MS identification. Three different glycol ethers potentially added as surfactants were detected in the Latex Effluent and the Latex Sludge Leachate. Fatty acids present in the latex effluent and sludge in major concentrations may also have resulted from their use as surfactants, but were more likely present due to cross-over. Linseed oil and other vegetable oils are common components of alkyd paints. Many fatty acid derivatives are also used as plasticizers and defoamers in emulsion paints. The presence of dispersing agents such as sodium phosphates and sodium silicates are evident from the metal analyses of the latex effluent, latex sludge, spent solvent sludge and paint skins.

3.4.5 Plasticizers - Phthalic Acid Esters

Diethyl phthalate had the highest concentration of the phthalic acid esters in the latex effluent, latex sludge leachate, spent solvent sludge and spent solvent sludge leachate. The paint skin leachate contained di-n-butyl phthalate and bis (2-ethyl hexyl) phthalate at 37 and 11 ug/g respectively but less than detectable concentrations of diethyl phthalate. Concentrations of the phthalic acid esters would be highly dependent on the type of paint or lacquer being manufactured prior to sample collection.

3.4.6 Plasticizers - Fatty Acids

A number of fatty acid derivatives are used as plasticizers in both latex and alkyd based paints. Fatty acids were present at high concentrations in the latex effluent, spent solvent leachate and paint skins leachate.

3.4.7 Preservatives

Tetrachlorophenol and pentachlorophenol were in relatively low concenration in both effluent, sludge and leachate samples. Mercury was detected at low concentrations in the latex effluent, potentially due to the use of phenyl mercury oleate or similar compounds as a fungicide. Copper and zinc present in the sludge is also potentially due to the use of napthenate preservatives.

3.4.8 Solvents

3.4.8.1 Latex Effluent

Solvents detected in the Latex Effluent at measurable concentrations included acetone, ethanol ethylbenzene, methanol, methyl ethyl ketone, xylenes, 2-butoxyethanol, and aliphatic hydrocarbons. The presence of xylenes and hydrocarbons in the latex effluent indicates that cross-over is taking place from the alkyd section to the latex section potentially due to spills and leaks.

3.4.8.2 Spent Solvent Sludge

Solvents detected included 2-butoxyethanol glycol ether A and aliphatic hydrocarbons.

6. PLANT D

6.1 PROCESS DESCRIPTION

Plant D is a paint and coatings manufacturer that produces latex, alkyd and clear coatings for commercial and consumer markets. Latex and alkyd paints represent approximately 52% and 45% respectively, of total production. Blending of both alkyd and latex paint formulations is carried out in batch mixing tanks which can be moved from the mixing stations to the canning section of the plant as required. Alkyd paint mixing tanks and equipment are cleaned with solvents. All spent solvent is recycled into the production of metal primers and stains. Latex equipment is washed with a restricted volume of water to minimize wastewater generation.

This latex washwater is stored for recycle into subsequent batches of latex paint. A small amount of excess washwater can overflow during tank washing. If the latex washwater cannot be utilized within approximately 72 hours it is discharged to a floor sump which overflows to the municipal sewer. Heavy solids in the washwater can settle in the sump. At the time of the sampling trip, the bulk of the waste water discharging to the sewer was cooling water originating from pigment and paint blending mills. The sump was free of solids at the time of sample collection.

6.2 SAMPLE DESCRIPTIONS

6.2.1 Combined Effluent

This sample was a composite collected from the floor sump at 2 minute intervals over a 4-hour period during canning and cleanup of three 1300 L batches of latex paint. Cooling water flow was continuous during this period at a rate of approximately 10L/min. Volume of washwater discharged to sewer during the first two batches was small, approximately 2-5 L. Most of washwater generated (20L) was stored for potential re-use. The third latex batch cleanup did not result in a discharge.

6.2.2 Tank Washing

This sample was an aliquot of the wash water from the third latex paint. This material was stored for re-use. This sample would represent a concentrated waste that would be discharged to sewer if it could not be re-used.

6.2.3 Baghouse Dust

This sample was a grab collected from the bottom of a small baghouse which removed dust from a waste bag crusher. The empty bags result from pigment, filler and other paint additives that are handled in the dry form. The quantity of dust collected is very small.

6.3 PRIORITY CHEMICALS - PLANT

6.3.1 Phthalic Acid Esters

Di-n-butyl, butyl benzyl and bis (2-ethyl hexyl) phthalates were an order of magnitude above detection limit in the tank washing, while butyl benzyl and bis (2-ethyl hexyl) were only slightly above detection limit in the combined effluent. The baghouse dust contained a major amount of di-n-butyl phthalate.

6.3.2 Chlorinated Phenols

Chlorinated phenols were not detected in either of the liquid since they would not be expected in a general latex formulation. Small amounts of both tetrachlorophenol and pentachlorophenol were encountered in the baghouse dust.

6.3.3 Triaryl Phosphate

Tributyl phosphate was detected in the baghouse dust but triphenyl and tricresyl phosphates were below detection limit in all samples.

6.3.4 Organotin

Organotin analyses were not performed due to the less than detectable concentration of total tin in the liquid and solid samples.

6.4 MAJOR COMPONENTS

Major waste components would be the basic components of latex paint, i.e. polyvinyl acetate, pigment, colloids etc.

6.4.1 Solvents

Solvents detected in the tank washing at measurable concentrations included aliphatic hydrocarbons, fatty acids, xylene, ethyl benzene, glycol ethers and ethanol.

All solvents were below detection limit in the combined effluent due to dilution with cooling water. Solvents detected in the baghouse dust were glycol ethers and fatty acids.

APPENDIX A

A.1. ANALYTICAL METHODOLOGY

A.1.1 GENERAL

The details of the analytical methodology are presented in the following sections. The analysis of all liquid and the majority of solid wastes was performed on a total or total extractable basis. In addition, all of the sludges and solid wastes were subjected to a leaching test followed by a total basis analysis of the leachate solution. The methods described are broken down into categories based on the various analytical groups.

All gas chromatography analyses were carried out using a Hewlett-Packard Model 5890 Gas Chromatograph coupled to a Hewlett-Packard Model 3392 Printer/Plotter Integrator. Details of the chromatographic conditions are presented in the relevant sections. All solvents used were of pesticide-grade (MCB Omnisolv). All other reagents were of reagent grade or better.

A.1.2 CONVENTIONAL PARAMETERS AND METALS

A representative aliquot of each of the liquid and solid waste samples was removed from the samples obtained from each of the plants and sent to the Cypress Creeek laboratory of the Environmental Protection Service located in West Vancouver, British Columbia. All analyses for conventional wastewater parameters and major and trace metals were carried out by that laboratory. Tables 1-1 through 3-6 inclusive.

A.1.3 SOLVENTS

All liquid effluents were analyzed for solvent compounds.

The technique used involved direct injection of the aqueous sample onto a gas chromatographic column. A direct injection technique was used so that both

water miscible solvents such as alcohol and ketones and slightly water soluble solvents such as toluene and benzene could be analyzed in a single analysis. This method also had the advantage of eliminating a number of factors that would affect the analyses using other techniques such as head space or liquid-liquid extraction.

The gas chromatographic column used was a 10 ft x 1/8" O.D. (4 mm I.D.) stainless steel column packed with 3% SP 1500 on 80/120 mesh Carbopack B. (Supelco).

The chromatographic conditions were as follows:

Temperatures	- Oven	: 70°C - 230°C at 4°C/min, hold for 5 min.
	- Injector	: 225°C
	- Detector	: 275°C
Column Flow		: 30 ml/min (Helium)
Attenuation		: 16
Range		: 1
Injection Volume		: 2 UL

Detection was carried out using a flame-ionization detector.

Calibration of the instrument and column for each compound with respect to retention time and detector response was achieved by injection of standard solutions prepared from pure reference materials. Water miscible compounds were dissolved in reagent grade (Milli-Q) water and diluted to various concentrations. Water immiscible solvents were first dissolved in methanol and then diluted with reagent grade water to the appropriate concentrations.

A.1.4 BASE NEUTRAL AND ACID FRACTIONS

Both liquid and solid samples were subjected to a generalized base-neutral and acid fraction extraction.

Solids samples were extracted in a similar manner except for a number of modifications made to accommodate the matrix. A representative portion of the sample was weighed into a 250 ml Erlenmeyer flask. Fifty ml of dichloromethane was added and the flask was sealed with precleaned aluminum foil and placed on a wrist action shaker and agitated for one hour. The residue was allowed to settle and the solvent decanted and filtered through anhydrous sodium sulphate and glass fibre filter paper (934 AH) into a second Erlenmeyer flask. A second 50 ml portion of dichloromethane was added to the extraction flask and agitated for one hour. The solvent was decanted and filtered and combined with the first extraction. Both the residue in the extraction flask and the sodium sulphate/glass fibre filter were washed numerous times with dichloromethane. One-half of the combined extract was then placed in a 250 ml separatory funnel. The extract was washed with two 50 ml portions of dilute sodium hydroxide (0.2N). The dichloromethane layer was then drawn off and filtered through anhydrous sodium sulphate and glass wool. This extract was then concentrated and reconstituted in 5.0 ml dichloromethane. This extract was labelled as the "base-neutral fraction". The aqueous wash was then adjusted to pH 2 with sulphuric aid (1 + 1) and extracted with two 50 ml portions of dichloromethane. This extract was filtered, concentrated, reconstituted and labelled as the "acid fraction"

The extracts were then analyzed by capillary column gas chromatorography. Both base-neutral and acid fractons were analyzed under identical conditions. The column used was a 25 meter by 0.31 millimeter I.D. fused silica capillary column coated with crosslinked 5% phenyl methyl silicone (Hewlett-Packard High Performance). The chromatographic conditions were as follows:

Temperatures to	- Oven	: 60°C, hold for 0.5 minute then 8°C/minute 270°C, hold for 15 minutes
	- Injector	: 225°C
	- Detector	: 275°C
Linear Velocity		: 30 cm/sec. (Helium)
Column Head Pressure		: 80 kPa
Injection Mode		: Splitless, 2.0 UL injection
Attentuation		: 16
Range		: 1

Detection was carried out using a flame ionization detector.

A.1.5 PHTHALIC ACID ESTERS

Phthalate ester compounds were determined by a modification of the US E.P.A. Method 606. For liquid samples, a 150 ml aliquot of sample was extracted with three 50 ml portions of dichloromethane. The resulting extracts were filtered through anhydrous sodium sulphate and glass wool and combined in a 250 ml round bottom flask. The extracts were then concentrated to just dryness on a rotary flash evaporator, reconstituted in 5.0 ml iso-octane and transferred to a glass vial.

For solids samples a portion of the crude dichloromethane extract was evaporated to just dryness and reconstituted with 5.0 ml iso-octane. The resulting extract was then transferred to a glass vial.

Analysis of the extracts was carried out using capillary column gas chromatography with electron capture detection. The column used was as per the analysis of the base-neutral and acid fractions. The chromatographic conditions were as follows:

Temperatures to	- Oven	: 60°C, hold for 0.5 minute then 8°C/minute 270°C, hold for 2minutes
	- Injector	: 200°C
	- Detector	: 325
Linear Velocity		: 30 cm/sec. (Helium)
Column Head Pressure		: 80 kPa
Injection Mode		: Splitless, 2 UL injection
Attentuation		: 256
Range		: 1

Six representative phthalate esters were used to calibrate the instrument:

- dimethyl phthalate
- diethyl phthalate
- di-n-butyl phthalate
- di-n-octyl phthalate
- bis (2-ethylhexyl) phthalate
- butyl benzyl phthalate

These compounds were chosen as they are included in the US E.P.A. priority pollutant list.

A generalized extraction was used such that the majority of the compounds present would be extracted. These extracts could then be used for the following purposes:

- to determine the complexity of the samples in terms of organic compounds present;
- to allow for comparisons between wastes within a plant and between different plants;
- to establish criteria for choosing extracts for subsequent analysis by gas chromatography/mass spectrometry;
- to allow quantitaiton of the identified compounds.

The extraction procedure generally followed that of the United States Environmental Protection Agencies priority pollutant analysis (1). Water samples were extracted on a total extractable basis. A 150 mL aliquot of the sample was adjusted to pH 12 with 10N sodium hydroxide. The sample was then separatory funnel extracted with 50 ml of dichloromethane. The solvent layer was then filtered through anhydrous sodium sulphate and glass wool into a 250 ml round bottom flask. The extraction was then repeated a second and third time with further 50 ml aliquots of dichlormethane. The aqueous layer was retained. The extracts were combined and then evaporated and concentrated using a rotary flesh evaporator. Evaporation was carried out to near dryness. The resulting extract was then reconstituted in 5.0 ml of dichloromethane and transferred to a glass vial. This was labelled as the "base-neutral fraction".

The retained aqueous portion was then adjusted to pH 2 with sulphuric acid (1 + 1). Extractions were then carried out as with the base-neutral fraction using three 50 mL aliquots of dichlormethane. The resulting extract was labelled as the "acid fraction".

A.1.6 CHLORINATED PHENOLS

Chlorinated phenols were determined by a modification of the US E.P.A. Method 604. For liquid samples a 150 ml aliquot of the sample was acidified to pH 2 with sulphuric acid (1 + 1) and extracted by liquid - liquid separatory funnel extraction using three 50 ml aliquots of dichlorometane. The extracts were filtered through anhydrous sodium sulphate and glass wool and combined in a 250 ml round bottom flask. The extract was then concentrated to just dryness, and reconstituted in 5.0 ml iso-octane and transferred to a glass vial. For solids samples a portion of the crude dichloromethane extract was evaporated to just dryness, reconstituted in 5.0 ml iso-octane and transferred to a glass vial.

Analysis of the extracts was carried out using gas chromatography with electron capture detection. The column used was a 5 meter by 0.53 mm I.D. fused silica wide-bore column coated with methyl silicone (Hewlett Packard Mega-bore). The chromatographic conditions were as follows:

Temperatures	- Oven	: 50°C, hold for 0.5 minute then 40°/minute to 180°C, then 2°C/min to 200°C
	- Injector	: 200°C
	- Detector	: 325
Carrier Gas Flowrate		: 12 ml/min
Injection Mode		: Splitless, 2 UL injection
Attenuation		: 256
Range		: 2

A.1.7 TRI-ARYL PHOSPHATES AND CHLORINATED PARAFFINS

The analysis for these groups of parameters was carried out on the extracts generated for the phthalate ester analysis. Analysis for the tri-aryl phosphates was performed using gas chromatography with flame ionization detection. The chromatographic conditions were identical to those used for base-neutral fraction analysis. Tri-phenyl phosphate and tri-cresyl phosphate were used to calibrate the instrument.

Analysis for chorinated paraffins was performed using gas chromatography with electron capture detection.

A.2. SPECIAL WASTE EXTRACTION PROCEDURE

All solid wastes were subjected to a test to determine the extent of leaching of organic compounds and conventional anions and cations from the solids matrix. The method used was that of the BC Ministry of the Environment Special Waste Extraction Procedure (SWEP) which is modelled after the US E.P.A. procedure. This test is used to simulate conditions in sanitary landfills by mixing a portion of the solid waste with water at a slightly acid pH for a period of 24 hours. One major modification was made to the published procedure in that dilute sulphuric acid was used to adjust the pH rather than the prescribed dilute acetic acid. This modification was made to facilitate the analysis of the leachate solution for total organic carbon, chemical oxygen demand and to eliminate possible interferences in the analyses of other organic parameters.

Specifically the procedure was as follows. Approximately 100 grams of solid waste material (de-watered where required) was accurately weighed and placed in a 1 litre glass container. Beakers were used for the majority of samples, except where it was suspected that the material could contain volatile solvents in which case Erlenmeyer flasks were used. To each sample was then added 1600 ml of reagent grade (Milli-Q) water.

Agitation of the mixture was the undertaken using a paddle mixer for samples contained in beakers and magnetic stirrers for samples contained in flasks. The top of each flask was covered in aluminum foil to avoid losses of volatile components.

The agitation was carried out for a period of 24 hours during which the pH of the suspension was monitored and adjusted down to pH 5.0 with 0.1 N sulphuric acid when necessary. Where the pH was below 5.0 no adjustment up to pH 5.0 was made. At the end of the 24 hour period reagent grade water was added to the mixture to bring the total volume of liquid (including added acid) up to 2000 ml. The mixture was then filtered through a 0.45 u membrane filter. The resulting leachate solution was analyzed for the organic parameters of interest as well as conventional parameters and metals. Extractions and analyses for organic parameters were carried out as for liquid waste samples.

A.3. GAS CHROMATOGRAPHY/MASS SPECTROMETRY ANALYSIS

A selected number of the base-neutral and acid fraciton extracts were also analyzed by gas chromatography/mass spectrometry (GC/MS). All GC/MS analyses were performed by Enviro-Test Laboratories of Edmonton, Alberta, using a Hewlett-Packard system. Each of the base-neutral extracts were subjected to a target compound search for the base-neutral and polycyclic aromatic hydrocarbon parameters in the US E.P.A. priority pollutant list. The acid extracts were subjected to a target search for the acidic parameters (phenols) on the priority pollutant list. The spectral data obtained on the extracts analyzed was also searched through an extensive library (National Bureau of Standards) of over 25,000 mass spectra to facilitate identification of the major components.

All raw data obtained from the GC/MS analysis was investigated by ASL to allow for comparisons between samples and plants and to finalize identification of the major components of the wastes.

A.4. QUALITY ASSURANCE PROGRAM

Quality assurance is an integral part of the management of a laboratory and includes day to day procedures such as calibration of instruments, balances, glassware, and standards. Quality assurance samples (ie. blanks, duplicates, spikes, etc) are analyzed at pre-determined intervals concurrently with the samples. The type of quality assurance samples selected is greatly dependent upon the program in question.

For this project, the analysis for conventional parameters and metals was carried out by the Environmental Protection Service laboratory at Cypress Creek. Details of the quality assurance program undertaken in that laboratory would be well known by the Scientific Authority.

For the analysis of the organic parameters carried out by ASL, the quality assurance program was designed to accommodate the great variation in the

TABLE A1 - ANALYSIS OF METHOD BLANKS
FOR PHTHALATE ESTERS

COMPOUND	No. of Occurrences	Average Value (mg/L)
Dimethyl Phthalate	0	-
Diethyl Phthalate	1	0.001
Di-n-butyl Phthalate	5	0.002
Butyl benzyl Phthalate	3	0.002
Bis (2-Ethylhexyl) Phthalate	10	0.004
Di-n-Octyl Phthalate	2	0.001

NOTE: Total Number of Blanks = 11

TABLE A2 - RECOVERY OF SPIKED COMPOUNDS

COMPOUND	Spike Level mg/L	Average Recovery (%)	Standard Deviation
Diethyl Phthalate	1.0	85.0	11.5
Di-n-octyl Phthalate	1.0	78.2	11.0
Tetrachlorophenol	1.0	81.3	14.7

NOTE: Number of Trials = 7

sample matrices as well as addressing the intent of the study. The primary focus was on the extraction and analysis of blanks. Due to the nature of many of the parameters under investigation, that is industrial chemicals in common use and proven or potential environmental contaminants, it was felt that this was of utmost importance. The analysis of blanks allows a monitoring of any contribution from reagents used in the analysis or from other sources such as laboratory apparatus or the laboratory atmosphere. In addition, one particular group of compounds under study, the phthalate esters, are used extensively as plasticizers in many common polymeric materials. Blank samples, using reagent grade (milli-Q) water, were carried through every step of the extraction and analysis for each set of sample extractions.

Spiked samples were also analyzed where specific target groups of priority chemical compounds were investigated. In the analysis for phthalate esters, two representative compounds, di-ethylphthalate and di-n-octyl phthalate were added to reageant grade water at concentrations calculated to be at a level of 1 mg/L in the final extract at 100 percent recovery. For chlorinated phenol analysis a tetrachlorophenol isomer was used. It is recognized that spiking reagent grade water is not ideal as analyte recovery can be greatly affected by the sample matrix. However, due to the highly diverse nature of the sample matrices involved in this project, spiking of actual samples would not be representative of the group.

A number of duplicate analyses were also carried out. Two effluent, two sludge and two leachate solutions were analyzed in duplicate as a check on the precision of each of the analyses.

Calibration of the gas chromatograph with respect to detector response and column retention times was achieved by injection of standard solutions of the compounds of interest. The solutions were prepared from pure materials (obtained from various sources) dissolved in the appropriate nanograde solvent. Various concentrations were injected to monitor detector response and linearity. The standard solutions were injected a number of times during each day of analysis of the extracts in order to monitor any changes in detector

performance and chromatographic column characteristics. Calculation of the concentrations of the compounds detected was achieved by comparison of the peak areas of the sample peaks versus the standard peaks. In some cases compounds were detected and identified by gas chromatography/mass spectrometry (GC/MS but standards were not available. For these compounds quantitation was achieved by assuming a detector response for the identified compounds based on structural and functional similarities to available standards. This yielded a valid estimate of the concentration of the compound.

Blank samples were concurrently extracted and analyzed during the base-neutral and acid extract phase of the organic analyses. The chromatograms obtained showed no major or minor peaks occurring at retention times matching those of reported compounds.

However the presence of phthalate ester compounds in extracted blanks during that phase of the analyses was noted. The average levels found are shown in Table A1. These levels are insignificant when compared to those found in samples.

As mentioned previously, phthalate esters are used extensively as plasticizers in many polymer materials. The complete removal or absence of phthalate esters from laboratory glassware and reagents is very difficult to achieve.

Blanks carried through the SWEP procedure showed no signs of contamination or interference, with one exception. In one set of extractions, all samples (including the blank) were found to contain a low concentration of 2-propanol. This was traced to its use in the laboratory in an area adjacent to the SWEP extraction area. As the concentration in each leachate solution was identical, the presence of this solvent was eliminated.

The results of the spiking experiments are shown in Table A2. The recoveries achieved are in the range of seventy or eighty percent, which is generally considered acceptable for extraction of organic compounds from water.

APPENDIX B

ANALYTICAL RESULTS
CONVENTIONAL AND ORGANIC ANALYSES

TABLE 1-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-BFD)

Program name: EPSAIC
Latest Rev: 17-Sep-85

PLANT A **** EFFLUENTS ****

Item	Description	Unit	Detection Limit	Latex Effluent	Latex Effluent
A	DATE SAMPLED			Feb 19/85	Feb 25/85
B	SAMPLE DESIGNATION			AE-1	AE-3
C	CONSTITUENTS				
	pH	NA	NA	5.4	6.5
	P. Alk. as CaCO3	mg/L	1	nil	
	T. Alk. as CaCO3	mg/L	1	142	299
	Sulphate (SO4)	mg/L	1	3200	3700
	Chloride (Cl)	mg/L	0.5	29	26.8
	Fluoride (F)	mg/L	0.05	L	L
	Total PO4 (P)	mg/L	0.005	1.7	1.9
	Nitrite (N)	mg/L	0.005	0.37	0.61
	Nitrate (N)	mg/L	0.005	0.23	L
	Ammonia (N)	mg/L	0.03	597	685
	Colour	Units	5	NA-Opaque	NA-Opaque
	Turbidity	FTU	1	2300	3900
	Conductivity	umhos/cm	1	7000	7100
	T.O.C.	mg/L	1	1690	1570
	T - N	mg/L	0.03	670	670
	Phenols	mg/L	0.02	0.148	0.11
	Non-Filterable Residue	mg/L	5	511	423
	Total Residue	mg/L	5	6250	6020
	COD	mg/L	20	5600	4750
	Oils & Grease	mg/L	2	28	737

TABLE 1-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-DFO)

Program name: EPSAIC
Latest Rev: 17-Sep-85

PLANT A **** EFFLUENTS ****

Item	Description	Unit	Detection Limit	Latex Effluent	Latex Effluent
A	DATE SAMPLED			Feb 19/85	Feb 25/85
B	SAMPLE DESIGNATION			AE-1	AE-3
D	METALS - ICP Scan				
	Arsenic -As	ug/ml	0.05	0.06	L
	Boron -B	ug/ml	0.001	0.268	0.184
	Barium -Ba	ug/ml	0.001	0.051	0.03
	Beryllium -Be	ug/ml	0.001	L	L
	Cadmium -Cd	ug/ml	0.002	0.012	0.004
	Cobalt -Co	ug/ml	0.005	1.51	1.3
	Chromium -Cr	ug/ml	0.005	0.153	0.029
	Copper -Cu	ug/ml	0.005	0.028	0.017
	Manganese -Mn	ug/ml	0.001	0.808	0.728
	Molybdenum -Mo	ug/ml	0.005	L	0.017
	Nickel -Ni	ug/ml	0.02	L	L
	Phosphorus -P	ug/ml	0.05	2.39	2.05
	Lead -Pb	ug/ml	0.02	1.02	0.22
	Antimony -Sb	ug/ml	0.05	0.07	L
	Selenium -Se	ug/ml	0.05	L	L
	Tin -Sn	ug/ml	0.01	L	L
	Strontium -Sr	ug/ml	0.001	0.123	0.107
	Titanium -Ti	ug/ml	0.002	0.596	0.166
	Vanadium -V	ug/ml	0.005	0.014	0.007
	Zinc -Zn	ug/ml	0.002	0.697	0.38
	Aluminum -Al	ug/ml	0.05	29	7.43
	Iron -Fe	ug/ml	0.005	4.92	1.58
	Silicon -Si	ug/ml	0.1	10.6	4.4
	Calcium -Ca	ug/ml	0.1	348	410
	Magnesium -Mg	ug/ml	0.1	4.1	4.1
	Sodium -Na	ug/ml	0.1	240	232
	-Replicates in Average	ug/ml		1	1
	-Dilution Factor	ug/ml		1:1	1:1
	-Hardness	ug/ml			
	Ca, Mg	ug/ml		886	1040
	Total	ug/ml		1060	1090
	Mercury (Hg)	ug/ml	0.00005	0.16	0.145
	-Replicates in Average	ug/ml		1	1
	-Dilution Factor	ug/ml		1:1	10:1
E	BIOASSAY				
	96 HOUR LT 50	hour		<0.17	

TABLE 1-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-DFO)

Program name: EPSDIC
Latest Rev: 17-Sep-85

PLANT D **** EFFLUENTS ****

Item	Description	Unit	Detection Limit	Combined Effluent
A	DATE SAMPLED			Mar 1/85
B	SAMPLE DESIGNATION			DE-17
C	CONSTITUENTS			
	pH	NA	NA	8.1
	T. Alk. as CaCO3	mg/L	1	17.2
	Sulphate (SO4)	mg/L	1	8
	Chloride (Cl)	mg/L	0.5	8
	Fluoride (F)	mg/L	0.05	L
	Total PO4 (P)	mg/L	0.005	0.50
	Nitrite (N)	mg/L	0.005	0.059
	Nitrate (N)	mg/L	0.005	0.14
	Colour	Units	5	NA-Opaque
	Turbidity	FTU	1	9900
	Conductivity	umhos/cm	1	46.8
	T.O.C.	mg/L	1	20
	T - N	mg/L	0.03	0.7
	Phenols	mg/L	0.02	0.06
	Non-Filterable Residue	mg/L	5	L
	Total Residue	mg/L	5	81
	COD	mg/L	20	40

TABLE 1-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-DFO)

Program name: EPSDIC
Latest Rev: 17-Sep-85

PLANT D **** EFFLUENTS ****

Item	Description	Unit	Detection Limit	Combined Effluent
A	DATE SAMPLED			Mar 1/85
B	SAMPLE DESIGNATION			DE-17
D	METALS - ICP Scan			
	Arsenic -As	ug/ml	0.05	L
	Boron -B	ug/ml	0.001	L
	Barium -Ba	ug/ml	0.001	0.007
	Beryllium -Be	ug/ml	0.001	L
	Cadmium -Cd	ug/ml	0.002	L
	Cobalt -Co	ug/ml	0.005	L
	Chromium -Cr	ug/ml	0.005	L
	Copper -Cu	ug/ml	0.005	0.039
	Manganese -Mn	ug/ml	0.001	0.019
	Molybdenum -Mo	ug/ml	0.005	L
	Nickel -Ni	ug/ml	0.02	L
	Phosphorus -P	ug/ml	0.05	0.08
	Lead -Pb	ug/ml	0.02	0.04
	Antimony -Sb	ug/ml	0.05	L
	Selenium -Se	ug/ml	0.05	L
	Tin -Sn	ug/ml	0.01	L
	Strontium -Sr	ug/ml	0.001	0.012
	Titanium -Ti	ug/ml	0.002	1.27
	Vanadium -V	ug/ml	0.005	L
	Zinc -Zn	ug/ml	0.002	0.07
	Aluminum -Al	ug/ml	0.05	0.45
	Iron -Fe	ug/ml	0.005	0.37
	Silicon -Si	ug/ml	0.1	1.9
	Calcium -Ca	ug/ml	0.1	6.9
	Magnesium -Mg	ug/ml	0.1	0.4
	Sodium -Na	ug/ml	0.1	1
	-Replicates in Average	ug/ml		1
	-Dilution Factor	ug/ml		1:1
	-Hardness	ug/ml		
	Ca, Mg	ug/ml		18.8
	Total	ug/ml		22.1
	Mercury (Hg)	ug/ml	0.00005	0.00036
	-Replicates in Average	ug/ml		2
	-Dilution Factor	ug/ml		1:1
E	BIOASSAY			
	96 HOUR LT 50	hour		NT

TABLE 2-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-FMS)

Program name: EPSACC
Latest Rev: 19-Sep-85

PLANT A **** SLUDGE ****

Item	Description	Unit	Detection Limit	Latex Sludge	Spent Solvent Sludge		Paint Skins	
A	DATE SAMPLED			Feb 19/85	Feb 25/85	Feb 25/85	Feb 25/85	Feb 25/85
B	SAMPLE DESIGNATION			AS-2	AS-3	AS-3	AS-6	AS-6
C	REPLICATES			A	A	B	A	B
D	CONSTITUENTS							
	Total Residue	mg/kg		173.000	660.000		635.000	
	% Moisture	%		82.7				
	Total Volatile Residue	mg/kg		94.500	43.500		298.000	
	COD	mg/kg		26.600				
	OAOV	%			2.9			
	Oils & Grease	mg/kg	100	14.000	11.200		64.300	
E	METALS - ICP Scan							
	Arsenic -As	ug/g	B	L	L	11	L	L
	Barium -Ba	ug/g		4.2	99.9	179	144	95.8
	Beryllium -Be	ug/g	0.2	L	0.2	0.2	L	L
	Cadmium -Cd	ug/g	0.3	L	L	L	35.8	34.2
	Cobalt -Co	ug/g	0.8	37.1	158	173	149	123
	Chromium -Cr	ug/g	0.8	73.7	465	540	429	437
	Copper -Cu	ug/g	0.8	12.6	20.2	22.7	67.2	63.7
	Manganese -Mn	ug/g		18.3	150	163	111	110
	Molybdenum -Mo	ug/g	0.8	L	16.3	23.8	3.6	14.2
	Nickel -Ni	ug/g	3	L	4	4	9	7
	Phosphorus -P	ug/g	8	565	276	285	602	522
	Lead -Pb	ug/g	3	303	3330	3630	5610	3560
	Tin -Sn	ug/g	2	L	7	6	110	72
	Strontium -Sr	ug/g	0.2	5	18.3	18.1	21.3	19.8
	Titanium -Ti	ug/g	0.3	484	110	100	439	490
	Vanadium -V	ug/g	0.8	12.6	4.2	4.5	7.4	6.1
	Zinc -Zn	ug/g	0.3	27.7	223	247	769	770
	Aluminum -Al	ug/g	8	24240	22100	21700	10300	9440
	Iron -Fe	ug/g	80	3020	5910	5560	9330	7090
	Silicon -Si	ug/g		6170	2080	2360	1790	1730
	Calcium -Ca	ug/g	20	2670	11900	13300	28200	30300
	Magnesium -Mg	ug/g	20	366	3450	3510	2160	1670
	Sodium -Na	ug/g	20	2930	13200	13100	3260	2960

TABLE 2-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-FMS)

Program name: EP5D2C
Latest Rev: 13-Sep-85

PLANT D **** SLUDGE ****

Item	Description	Unit	Detection Limit	Baghouse Dust	Baghouse Dust
A	DATE SAMPLED			Mar 1/85	Mar 1/85
B	SAMPLE DESIGNATION			DS-19	DS-19
C	REPLICATES			A	B
D	CONSTITUENTS				
	Total Residue	ug/kg		990,000	
	Total Volatile Residue	ug/kg		113,000	
	Oils & Grease	ug/kg		6,160	
E	METALS - ICP Scan				
	Arsenic -As	ug/g	8	L	L
	Barium -Ba	ug/g		902	878
	Beryllium -Be	ug/g	0.2	L	L
	Cadmium -Cd	ug/g	0.3	L	L
	Cobalt -Co	ug/g	0.8	1.6	5.3
	Chromium -Cr	ug/g	0.8	625	601
	Copper -Cu	ug/g	0.8	43.6	40.5
	Manganese -Mn	ug/g		888	866
	Molybdenum -Mo	ug/g	0.8	L	L
	Nickel -Ni	ug/g	3	5	5
	Phosphorus -P	ug/g	8	543	534
	Lead -Pb	ug/g	3	872	869
	Tin -Sn	ug/g	2	L	L
	Strontium -Sr	ug/g	0.2	64.6	62.4
	Titanium -Ti	ug/g	0.3	561	537
	Vanadium -V	ug/g	0.8	21.8	21.1
	Zinc -Zn	ug/g	0.3	4270	4150
	Aluminum -Al	ug/g	8	13600	13200
	Iron -Fe	ug/g	80	23200	22500
	Silicon -Si	ug/g		1880	1420
	Calcium -Ca	ug/g	20	52600	51000
	Magnesium -Mg	ug/g	20	12700	12400
	Sodium -Na	ug/g	20	2590	2510

TABLE 3-1

SISNA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-FMS)

Program name: EPSAOC
Latest Rev: 17-Sep-85

PLANT A **** LEACHATES ****

Item	Description	Unit	Detection Limit	Latex Sludge Leachate	Spent Solvent Sludge Leachate	Paint Skins Sludge Leachate
A	DATE SAMPLED			Feb 19/85	Feb 25/85	Feb 25/85
B	SAMPLE DESIGNATION			ASL-2	ASL-5	ASL-6
C	REPLICATES			A	A	A
D	CONSTITUENTS					
	T.O.C.	ug/g	20	5770	6230	58000
	T.I.C.	ug/g	20	55	50	104
	Phenols	ug/g	0.4	3.6	6	10.8
	Oils & Grease	ug/g	40	350	L	4,620
E	METALS - IPC Scan					
	Arsenic -As	ug/g	1	L	L	L
	Boron -B	ug/g	0.02	0.4	0.47	3.4b
	Barium -Ba	ug/g	0.02	0.31	0.27	0.52
	Beryllium -Be	ug/g	0.02	L	L	L
	Cadmium -Cd	ug/g	0.04	0.036	0.12	2.44
	Cobalt -Co	ug/g	0.1	2.7	40	10.76
	Chromium -Cr	ug/g	0.1	0.13	2.9	0.96
	Copper -Cu	ug/g	0.1	0.11	0.92	3.56
	Manganese -Mn	ug/g	0.02	1.35	32	3.34
	Molybdenum -Mo	ug/g	0.1	L	L	0.26
	Nickel -Ni	ug/g	0.4	L	L	L
	Phosphorus -P	ug/g	1	1.6	3.5	27.6
	Lead -Pb	ug/g	0.4	43	35.9	25.8
	Antimony -Sb	ug/g	1	L	5.5	2.4
	Selenium -Se	ug/g	1	L	L	L
	Tin -Sn	ug/g	0.2	L	L	L
	Strontium -Sr	ug/g	0.02	0.51	1	0.82
	Titanium -Ti	ug/g	0.04	L	L	0.88
	Vanadium -V	ug/g	0.1	L	L	0.16
	Zinc -Zn	ug/g	0.04	1.83	16.1	15.98
	Aluminum -Al	ug/g	1	110	8	18.6
	Iron -Fe	ug/g	0.1	7	0.33	15.92
	Silicon -Si	ug/g	2	24	100	52
	Calcium -Ca	ug/g	2	675	1333	984
	Magnesium -Mg	ug/g	2	7.3	190	32
	Sodium -Na	ug/g	2	220	352	272
	-Dilution Factor			1:1	1:1	1:1
	Ca, Mg	ug/g		1720	4110	2600
	Total	ug/g		2350	4240	2760

TABLE 3-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - LABORATORY SERVICES (EPS-FMS)

Program name: EPSDJC
Latest Rev: 13-Sep-85

PLANT D **** LEACHATE ****

Item	Description	Unit	Detection Limit	Baghouse Dust Leachate
A	DATE SAMPLED			Mar 1/85
B	SAMPLE DESIGNATION			DSL-19
C	REPLICATES			A
D	CONSTITUENTS			
	T.O.C.	ug/g	20	12860
	T.I.C.	ug/g	20	100
	Phenols	ug/g	0.4	2.4
	Oils & Grease	ug/g	40	L
E	METALS - ICP Scan			
	Arsenic -As	ug/g	1	L
	Boron -B	ug/g	0.02	4.72
	Barium -Ba	ug/g	0.02	0.36
	Beryllium -Be	ug/g	0.02	L
	Cadmium -Cd	ug/g	0.04	0.14
	Cobalt -Co	ug/g	0.1	0.18
	Chromium -Cr	ug/g	0.1	167.2
	Copper -Cu	ug/g	0.1	0.24
	Mercury -Hg	ug/g	0.001	
	Manganese -Mn	ug/g	0.02	34.8
	Molybdenum -Mo	ug/g	0.1	L
	Nickel -Ni	ug/g	0.4	L
	Phosphorus -P	ug/g	1	8.6
	Lead -Pb	ug/g	0.4	0.8
	Antimony -Sb	ug/g	1	3.2
	Selenium -Se	ug/g	1	L
	Tin -Sn	ug/g	0.2	L
	Strontium -Sr	ug/g	0.02	14.02
	Titanium -Ti	ug/g	0.04	18.82
	Vanadium -V	ug/g	0.1	L
	Zinc -Zn	ug/g	0.04	596
	Aluminum -Al	ug/g	1	6.8
	Iron -Fe	ug/g	0.1	1.5
	Silicon -Si	ug/g	2	190
	Calcium -Ca	ug/g	2	9640
	Magnesium -Mg	ug/g	2	634
	Sodium -Na	ug/g	2	1106
	-Dilution Factor			1:1
	-Hardness			
	Ca, Mg	ug/g		26600
	Total	ug/g		27800

TABLE 4-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMset
Latest revision: 17-Sep-85

PLANT A **** EFFLUENT (TOTAL) ****

Item	Description	Unit	Detection Limit	Latex Effluent
A	DATE SAMPLED			Feb 25/85
B	ASL SAMPLE #			1630-2
C	SIGMA SAMPLE #			AE-2
D	ORGANIC COMPONENTS			
	Diaethyl Phthalate	ug/L	0.01	L
	Diethyl Phthalate	ug/L	0.01	0.36
	Di-n-butyl Phthalate	ug/L	0.001	0.024
	Butyl Benzyl Phthalate	ug/L	0.001	0.009
	Bis (2-Ethyl Hexyl) Phthalate	ug/L	0.001	0.036
	Di-n-octyl Phthalate	ug/L	0.001	L
	Tetrachlorophenol	ug/L	0.001	0.083
	Pentachlorophenol	ug/L	0.001	0.066
	Acetone	ug/L	0.5	38
	Benzene	ug/L	0.2	0.96
	Ethanol	ug/L	0.5	51
	Ethylbenzene	ug/L	0.2	10
	Methanol	ug/L	0.5	190
	Methyl Ethyl Ketone	ug/L	0.5	57
	Toluene	ug/L	0.2	3.6
	Xylenes	ug/L	0.2	57
	2-Butoxyethanol	ug/L	0.01	5.1
	Glycol Ether A (n.p.i)	ug/L	0.01	1.4
	Glycol Ether B (n.p.i)	ug/L	0.01	1.4
	Glycol Ether C (n.p.i)	ug/L	0.01	1.5
	Fatty Acids	ug/L	0.5	150
	Aliphatic Hydrocarbons (C7-C13)	ug/L	0.05	450
	Aliphatic Hydrocarbons (C19-C30)	ug/L	0.5	700
	Parameters Below Detection Limit:			
	2-Phenoxyethanol	ug/L	0.01	
	Acetaldehyde	ug/L	0.5	
	Benzoic Acid	ug/L	0.01	
	Butylated Hydroxytoluene (BHT)	ug/L	0.01	
	Diethylene Glycol	ug/L	0.01	
	Dipropylene Glycol	ug/L	0.01	
	Methyl Isobutyl Ketone	ug/L	0.5	
	Phthalic Acid	ug/L	0.01	
	Propionaldehyde	ug/L	0.5	
	Styrene	ug/L	0.2	
	Tributyl Phosphate	ug/L	0.01	

TABLE 4-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMnet
Latest revision: 17-Sep-85

PLANT D **** EFFLUENT (TOTAL) ****

Item	Description	Unit	Detection Limit	Combined Effluent	Tank Washing
A	DATE SAMPLED			Mar 1/85	Mar 1/85
B	ASL SAMPLE #			1630-17	1630-18
C	SIGMA SAMPLE #			DE-17	DE-18
D	ORGANIC COMPONENTS				
	Diethyl Phthalate	ug/L	0.01	L	L
	Diethyl Phthalate	ug/L	0.01	L	L
	Di-n-butyl Phthalate	ug/L	0.001	L	0.061
	Butyl Benzyl Phthalate	ug/L	0.001	0.004	0.022
	Bis (2-Ethyl Hexyl) Phthalate	ug/L	0.001	0.006	0.048
	Di-n-octyl Phthalate	ug/L	0.001	L	L
	Tetrachlorophenol	ug/L	0.001	L	L
	Pentachlorophenol	ug/L	0.001	L	L
	Acetone	ug/L	0.5	L	1.3
	Ethanol	ug/L	0.5	L	6.6
	Ethylbenzene	ug/L	0.2	L	34
	Xylenes	ug/L	0.2	L	46
	2-Phenoxyethanol	ug/L	0.01	L	3.1
	Butylated Hydroxytoluene (BHT)	ug/L	0.01	L	0.32
	Glycol Ether A (n.p.i.)	ug/L	0.01	L	3.3
	Glycol Ether B (n.p.i.)	ug/L	0.01	L	31
	Glycol Ether C (n.p.i.)	ug/L	0.01	L	30
	Fatty Acids	ug/L	0.5	L	100
	Aliphatic Hydrocarbons (C7-C13)	ug/L	0.05	L	300
	Aliphatic Hydrocarbons (C19-C30)	ug/L	0.5	L	150
	Parameters Below Detection Limits:				
	2-Butoxyethanol	ug/L	0.01		
	Acetaldehyde	ug/L	0.5		
	Benzene	ug/L	0.2		
	Diacetone Alcohol	ug/L	0.005		
	Diphenyl Ether	ug/L	0.005		
	Methanol	ug/L	0.5		
	Methyl Ethyl Ketone	ug/L	0.5		
	Methyl Isobutyl Ketone	ug/L	0.5		
	Propionaldehyde	ug/L	0.5		
	Styrene	ug/L	0.2		
	Toluene	ug/L	0.2		
	Toluene 2.4-Diisocyanate(TDI)	ug/L	0.01		

TABLE 5-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMast
Latest revision: 17-Sep-85

PLANT A **** SLUDGE (TOTAL) ****

Item	Description	Unit	Detection Limit	Spent Solvent Sludge
A	DATE SAMPLED			Feb 25/85
B	ASL SAMPLE #			1630-5
C	SIGMA SAMPLE #			AS-5
D	ORGANIC COMPONENTS			
	Dimethyl Phthalate	ug/g	0.5	L
	Diethyl Phthalate	ug/g	0.5	14
	Di-n-butyl Phthalate	ug/g	0.05	4.1
	Butyl Benzyl Phthalate	ug/g	0.05	0.1
	Bis (2-Ethyl Hexyl) Phthalate	ug/g	0.05	2.35
	Di-n-octyl Phthalate	ug/g	0.05	L
	Tetrachlorophenol	ug/g	0.01	0.76
	Pentachlorophenol	ug/g	0.01	0.96
	2-Butoxyethanol	ug/g	1	16
	Glycol Ether A (n.p.i)	ug/g	1	22
	Fatty Acids	ug/g	20	1500
	Aliphatic Hydrocarbons(C7-C13)	ug/g	2	75000
	Parameters Below Detection Limits:			
	2-Phenoxyethanol	ug/g	1	
	Aliphatic Hydrocarbons(C19-C30)	ug/g	20	
	Benzoic Acid	ug/g	1	
	Biphenyl	ug/g	0.5	
	Butylated Hydroxytoluene (BHT)	ug/g	1	
	Diphenyl Ether	ug/g	0.5	
	Glycol Ether B (n.p.i)	ug/g	1	
	Glycol Ether C (n.p.i)	ug/g	1	
	Phthalic Acid	ug/g	1	
	Toluene 2,4-Diisocyanate(TDI)	ug/g	1	
	Tributyl Phosphate	ug/g	1	

TABLE 5-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMdst
Latest revision: 17-Sep-95

PLANT D **** SLUDGE (TOTAL) ****

Item	Description	Unit	Detection Limit	Baghouse Dust
A	DATE SAMPLED			Mar 1/95
B	ASL SAMPLE #			1630-19
C	SIGMA SAMPLE #			D5-19
D	ORGANIC COMPOUNDS			
	Dimethyl Phthalate	ug/g	0.5	L
	Diethyl Phthalate	ug/g	0.5	L
	Di-n-butyl Phthalate	ug/g	0.05	4000
	Butyl Benzyl Phthalate	ug/g	0.05	L
	Bis (2-Ethyl Hexyl) Phthalate	ug/g	0.05	L
	Di-n-octyl Phthalate	ug/g	0.05	L
	Tetrachlorophenol	ug/g	0.01	8.3
	Pentachlorophenol	ug/g	0.01	4.6
	Tributyl Phosphate	ug/g	1	6
	Glycol Ether A (n.p.i)	ug/g	1	7.8
	Glycol Ether B (n.p.i)	ug/g	1	560
	Glycol Ether C (n.p.i)	ug/g	1	740
	Fatty Acids	ug/g	20	150
	Parameters Below Detection Limits:			
	2-Butoxyethanol	ug/g	1	
	2-Phenoxyethanol	ug/g	1	
	Aliphatic Hydrocarbons(C19-C30)	ug/g	20	
	Aliphatic Hydrocarbons(C7-C13)	ug/g	2	
	Butylated Hydroxytoluene (BHT)	ug/g	1	
	Diacetone Alcohol	ug/g	0.5	

TABLE 6-1

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMasi
Latest revision: 17-Sep-85

PLANT A **** SLUDGE (LEACHATE) ****

Item	Description	Unit	Detection Limit	Latex Sludge Leachate	Spent Solvent Sludge Leachate	Paint Skins Sludge Leachate
A	DATE SAMPLED			Feb 19/85	Feb 25/85	Feb 25/85
B	ASL SAMPLE #			1630-2	1630-5	1630-6
C	SIGMA SAMPLE #			ASL-2	ASL-5	ASL-6
D	ORGANIC COMPONENTS					
	Diethyl Phthalate	ug/g	0.2	L	L	L
	Diethyl Phthalate	ug/g	0.2	1.5	0.5	L
	Di-n-butyl Phthalate	ug/g	0.02	0.18	0.36	37
	Butyl Benzyl Phthalate	ug/g	0.02	0.06	0.04	0.39
	Bis (2-Ethyl Hexyl) Phthalate	ug/g	0.02	L	0.08	11
	Di-n-octyl Phthalate	ug/g	0.02	L	L	L
	Tetrachlorophenol	ug/g	0.01	0.31	0.67	0.66
	Pentachlorophenol	ug/g	0.01	0.05	0.7	0.9
	Acetone	ug/g	10	86	17	530
	Benzene	ug/g	4	L	6	L
	Ethanol	ug/g	10	55	170	49
	Ethylbenzene	ug/g	4	240	400	62
	Methanol	ug/g	10	160	1600	3800
	Methyl Ethyl Ketone	ug/g	10	64	230	22
	Methyl Isobutyl Ketone	ug/g	10	27	21	L
	Toluene	ug/g	4	95	110	L
	Xylenes	ug/g	4	880	1700	330
	2-Butoxyethanol	ug/g	0.2	16	10	L
	Butylated Hydroxytoluene(BHT)	ug/g	0.2	0.4	0.33	0.87
	Glycol Ether (n.a.i.)	ug/g	0.2	200	L	2.5
	Glycol Ether (n.p.i.)	ug/g	0.2	170	L	2.2
	Glycol Ether (n.p.i.)	ug/g	0.2	80	L	L
	Fatty Acids	ug/g	10	400	1000	500
	Aliphatic Hydrocarbons(C7-C13)	ug/g	1	L	3	L
	Aliphatic Hydrocarbons(C19-C30)	ug/g	10	L	L	150
	Diethylene Glycol	ug/g	0.2	15	L	L
	Parameters Below Detection Limits:					
	2-Phenoxyethanol	ug/g	0.2			
	Acetaldehyde	ug/g	10			
	Benzoic Acid	ug/g	0.2			
	Biphenyl	ug/g	0.05			
	Diacetone Alcohol	ug/g	0.02			
	Diphenyl Ether	ug/g	0.05			
	Dipropylene Glycol	ug/g	0.2			
	Phthalic Acid	ug/g	0.2			
	Propionaldehyde	ug/g	10			
	Styrene	ug/g	4			
	Toluene 2,4-Diisocyanate(TDI)	ug/g	0.2			
	Tributyl Phosphate	ug/g	0.2			

TABLE 6-4

SIGMA RESOURCE CONSULTANTS
WASTE CHARACTERIZATION STUDY
ANALYTICAL RESULTS - ASL LTD.

Program name: CHEMds1
Latest revision: 17-Sep-85

PLANT D **** SLUDGE (LEACHATE) ****

Item	Description	Unit	Detection Limit	Baghouse Dust Leachate
A	DATE SAMPLED			Mar 1/85
B	ASL SAMPLE #			1630-19
C	SIGMA SAMPLE #			DSL-19
D	ORGANIC COMPONENTS			
	Diethyl Phthalate	ug/g	0.2	L
	Diethyl Phthalate	ug/g	0.2	L
	Di-n-butyl Phthalate	ug/g	0.02	0.23
	Butyl Benzyl Phthalate	ug/g	0.02	L
	Bis (2-Ethyl Hexyl) Phthalate	ug/g	0.02	L
	Di-n-octyl Phthalate	ug/g	0.02	L
	Tetrachlorophenol	ug/g	0.01	0.4
	Pentachlorophenol	ug/g	0.01	0.7
	2-Phenoxyethanol	ug/g	0.2	210
	2-Butoxyethanol	ug/g	0.2	5.9
	Tributyl Phosphate	ug/g	0.2	5
	Butylated Hydroxytoluene(BHT)	ug/g	0.2	4.2
	Glycol Ether A (n.p.i)	ug/g	0.2	240
	Glycol Ether B (n.p.i)	ug/g	0.2	320
	Glycol Ether C (n.p.i)	ug/g	0.2	240
	Fatty Acids	ug/g	10	4000
	Diethylene Glycol	ug/g	0.2	2.1
	Parameters Below Detection Limits:			
	Acetaldehyde	ug/g	10	
	Acetone	ug/g	10	
	Aliphatic Hydrocarbons(C19-C30)	ug/g	10	
	Aliphatic Hydrocarbons(C7-C13)	ug/g	1	
	Benzene	ug/g	4	
	Diacetone Alcohol	ug/g	0.02	
	Dipropylene Glycol	ug/g	0.2	
	Ethanol	ug/g	10	
	Ethylbenzene	ug/g	4	
	Methanol	ug/g	10	
	Methyl Ethyl Ketone	ug/g	10	
	Methyl Isobutyl Ketone	ug/g	10	
	Propionaldehyde	ug/g	10	
	Styrene	ug/g	4	
	Toluene	ug/g	4	
	Toluene 2,4-Diisocyanate(TDI)	ug/g	0.2	
	Xylenes	ug/g	4	

TABLE 9 - VOLUMETRIC LOADINGS

Sample	Discharge Frequency	Quantity	Daily Flowrate m^3	Disposal Method
Plant A				
Latex Effluent AE-1 AE-3	Biweekly	11 m^3	0.8	Sewer
Latex Sludge AS-2	Annual	14 m^3	0.04	Cemented & Landfill
Spend Solvent Sludge AS-5	Monthly	0.2 m^3	0.007	Stored on Site
Paint Skins AS-6	Weekly	0.03 m^3	0.004	Landfill
Plant B				
Final Effluent BE-7	Continuous	150 m^3/d	150 m^3/d	Sewer
Primary Sludge BS-10	Annual	10 m^3	.027	Dried & Landfill
Filter Press Paper BS-11	Weekly	N/A		Landfill

TABLE 10 - MASS LOADINGS - PLANT A

Parameter	kg/yr
Latex Effluent	
Phthalates	0.18
Chlorophenols	0.04
Aliphatic Hydrocarbons (C19-30)	200
Aliphatic Hydrocarbons (C7-C13)	129
Methanol	55
Fatty Acids	43
Methyl Ethyl Ketone	16
Xylenes	16
Ethanol	15
Acetone	11
Ethylbenzene	3
Spent Solvent Sludge	
Phthalates	.06
Chlorophenols	.005
Aliphatic Hydrocarbons (C6-C13)	216
Fatty Acids	4.3
Glycol Ether A	0.06
2-Butoxyethanol	0.05

LIST OF ABBREVIATIONS AND DEFINITIONS

CAOV	-	Chromic Acid Oxygen Value, equivalent to COD
COD	-	Chemical Oxygen Demand
GC	-	Gas Chromatography
ICP	-	Induction Coupled Plasma
L	-	Less than Detection Limit
NA	-	Not applicable
N/A	-	Not Available
NFR	-	Nonfilterable Residue
n.p.i.	-	not positively identified
MS	-	Mass Spectrometry
T.I.C.	-	Total Inorganic Carbon
T.O.C.	-	Total Organic Carbon
T-N	-	Total Nitrogen
TR	-	Total Residue
TVR	-	Total Volatile Residue

APPENDIX III

APPENDIX III LIST OF REGISTERED ANTIMICROBIAL PAINT ADDITIVES FOR USE IN CANADA
List Valid to October 13, 1985 (16)

COMPANY	REGN	MARK	PRODUCT NAME	ACTIVE INGREDIENT	GUARANTEE
Abbot Laboratories	15320	C	Amical 48 Antimicrobial Agent	Diodofon	95
	15322	C	Amical 50 Antimicrobial Agent	Diodofon	75
Bow Chemical Co.	17725	C	Sontox	Sodium Pentachlorophenate Plus Related Chlorophenates	90
Buckman Labs of Canada Ltd.	12008	C	Busan 52	Potassium N-Hydroxymethyl-N-Methyldithiocarbamate	32
				Sodium Salt of 2-mercaptobenzothiazole	8
	12033	C	Busan 11-M1	Barium Metaborate Monohydrate	90
	12115	C	Busan 40	Potassium N-Hydroxymethyl-N-Methyldithiocarbamate	40
	14506	C	Busan 30	2-(Thiocyanomethylthio)Benzothiazole	30
	16000	C	Bufen 30	Phenylmercuric Acetate	30
	17990	C	Busan 1030 Liquid Microbiocide Concentrate	2-(Thiocyanomethylthio)Benzothiazole	30
	18447	C	Busan 1005 Liquid Microbiocide	2-(2-Hydroxypropyl)Thiomethane Sulfonate	10.0
	18925	C	Busan 30L	2-(Thiocyanomethylthio)Benzothiazole	30
C.I.L. ICI & Resale Chem.	11922	C	Proxel CRL	1,2-Benzisothiazolin-3 One	28
				2,2'-Dithiobisbenzamide	4.5
	14683	C	Proxel GXL	1,2-Benzisothiazolin-3 One	19.0
Calgon Canada	13995	C	Metasol TK-100 Powder	Thiabendazole	98.5
	14755	C & M	Tektamer 38	1,2-Dibromo-2,4-Dicyanobutane	98
	16771	C	Tektamer 38 Liquid Concentrate	1.2-Dibromo-2,4-Dicyanobutane	25
	17325	C	Tektamer 38 A.D.	1,2-Dibromo-2,4-Dicyanobutane	25
	17326	C	Tektamer 38 Liquid Concentrate Special	1,2-Dibromo-2,4-Dicyanobutane	25

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APPENDIX III LIST OF REGISTERED ANTIMICROBIAL PAINT ADDITIVES FOR USE IN CANADA
List Valid to October 13, 1985 (16)

(Continued)

COMPANY	REGN	MARK	PRODUCT NAME	ACTIVE INGREDIENT	GUARANTEE
Chapman Chemical Ltd.	15574	C	Napclor-S	Sodium Pentachlorophenate Plus Related Chlorophenates	90
Cosan Chemical Canada Ltd.	15601	C	Cosan PMO-30	Phenylmercuric Oleate	30
	15602	C	Cosan PMA-30	Phenylmercuric Acetate	30
	15603	C	Cosan PMA-100 WSB	Phenylmercuric Acetate	100
	15604	C	Cosan 171-S	N-Phenylmercuriethylenediamide	25
Dow Chemical of Canada Ltd.	11974	C & M	Dowicide EC-7 Antimicrobial	Pentachlorophenol Plus Related Active Chlorophenols	100
	11980	C & M	Dowicide 1 Antimicrobial	O-Phenylphenol	98
	11991	C & M	Dowicide A Antimicrobial	Sodium O-Phenylphenate	97
	11995	C & M	Dowicil 75 Preservative	1-(3-Chloroallyl)-3,5,7-Triaza-1-Azonia-Adamantane Chloride (Cis Isomer)	67.5
Drew Chemical Ltd.	15918	C	Amestat 233	Dazomet	24
Gray Products	14373	C	Parmetol K-50	Benzyl Alcohol	23.0
				Chloroacetamide	13.0
				Paraformaldehyde	8.0
				Triethylene Glycol	25.0
Interstab Chemicals Inc.	15610	C	Intercide PMA-18	Phenylmercuric Acetate	30
	16848	C	Copper Naphthenate 6% Liquid Antifungal Agent	Copper as Elemental, Present as Copper Naphthenate	6
	17141	C	Intercide PMO-11	Phenylmercuric Oleate	11

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APPENDIX III LIST OF REGISTERED ANTIMICROBIAL PAINT ADDITIVES FOR USE IN CANADA
List Valid to October 13, 1985 (16)

(Continued)

COMPANY	REGN	MARK	PRODUCT NAME	ACTIVE INGREDIENT	GUARANTEE
Maag Agrochemicals Inc.	16512	C	Nytek-10	Copper 8-Quinolinolate	10
	16513	C	Nytek-GD	Copper 8-Quinolinolate	10
Nuodex Canada Ltd.	14942	C	Nuodex PMA-18	Phenylmercuric Acetate	30
	14943	C	Nuodex PMD-10 Paint Preservative	Mercury as Elemental, Present as Phenylmercuric Salts of Dodecenyl Succinic and Tall Oil Fatty Acids	11
	14944	C	Nuodex Super Ad It Paint Preservative	Di(Phenylmercuric)Dodecenyl Succinate	16
	14945	C	Nuodex PMA-60	Phenylmercuric Acetate	100
	15605	C	Nuodex Fungitrol II	Folpet	88
SDS Biotech Corp.	16354	C	Nopcocide N-96	Chlorothalonil	96
Thiokol/Ventrol Div.	11940	C	Durotex-7603 Bacteriostat & Fungistat	10,10'-Oxybisphenoxarsine	2
	11941	C	Durotex-7599 Bacteriostat & Fungistat	10,10'-Oxybisphenoxarsine	2
	11942	C	Durotex-7604 Bacteriostat & Fungistat	10,10'-Oxybisphenoxarsine	2
	12253	C	Cumilate 2174-ND Fungistatic & Bacteriostatic Additive	Copper 8-Quinolinolate	10
	12254	C	Cumilate 2174-NA Fungistatic & Bacteriostatic Additive	Copper 8-Quinolinolate	10
Thomson Research	12900	C	Durafresh DM 40 Germistat	Tri-N-Butyltin Methacrylate	40.1
	14498	C	Ultra-Fresh DM-50N Germistat	Tri-N-Butyltin Maleate	21

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APPENDIX III LIST OF REGISTERED ANTIMICROBIAL PAINT ADDITIVES FOR USE IN CANADA
List Valid to October 13, 1985 (16)

(Continued)

COMPANY	REGN	MARK	PRODUCT NAME	ACTIVE INGREDIENT	GUARANTEE
Vanderbilt, R.T. Co. Inc.	13875	C	Vancide 51Z	Zinc 2-Mercaptobenzothiazole	7.5
				Ziram	87.0
	13876	C	Vancide PA Paint Mold Inhibitor	Trans-1,2-Bis(N-Propylsulfonyl)Ethene	95
	13877	C	Vancide 89	Captan	90